AD-759 835

Ms vs mb CHARACTERISTICS OF EARTHQUAKES IN THE EASTERN HIMALAYAN REGIONS

Zoltan A. Der

Teledyne Geotech

Prepared for:

Air Force Technical Applications Center
Advanced Research Projects Agency

16 January 1973

296

AD 759835

M_s - m_b CHARACTERISTICS OF EARTHQUAKES IN THE EASTERN HIMALAYAN REGIONS

Z. A. DER
SEISMIC DATA LABORATORY

16 JANUARY 1973

Prepared for
AIR FORCE TECHNICAL APPLICATIONS CENTER
Washington, D.C.

Under
Project VELA UNIFORM

Sponsored by
ADVANCED RESEARCH PROJECTS AGENCY
Nuclear Monitoring Research Office
ARPA Order No. 1714

TELEDYNE GEOTECH
ALEXANDRIA LABORATORIES

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

R

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY (Corporate author) Teledyne Geotech Alexandria, Virginia	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP
3 REPORT TITLE M_s vs m_b CHARACTERISTICS OF EARTHQUAKES IN THE EASTERN HIMALAYAN REGIONS	
4 DESCRIPTIVE NOTES (Type of report and inclusive dates) Scientific	
5 AUTHOR(S) (Last name, first name, initial) Der, Zoltan, A.	
6 REPORT DATE 16 January 1973	7a TOTAL NO OF PAGES 76 7b NO OF REFS 22
8a CONTRACT OR GRANT NO. F33657-72-C-0009 b PROJECT NO VELA T/2706 c ARPA Order No. 1714 d ARPA Program Code No. 2F-10	9a ORIGINATOR'S REPORT NUMBER(S) 296 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
10 AVAILABILITY/LIMITATION NOTICES APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.	
11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency Nuclear Monitoring Research Office Washington, D.C.

13 ABSTRACT

The results of a study of M_s vs m_b characteristics of earthquakes in the Eastern Himalayan region are given in this report. It is shown that in this region some earthquakes occur which have M_s vs m_b characteristics similar to explosions, exhibiting low surface wave magnitudes relative to body wave magnitudes, when seen at the reporting stations available to this study. The application of station corrections does not change the general distribution and spread of points in the M_s vs m_b plane, and therefore it is unlikely that station (or path) effects are the source of the anomalies. Focal depths of most of the events studied are shallow or normal and can also be ruled out as causes of low surface wave magnitudes. The geographical distribution of anomalous events correlates with various prominent geological features and probably reflects the distribution of tectonic stress in the area studied. The existence of these anomalous events in certain areas of the world can seriously decrease the effectiveness of the M_s vs m_b criterion in discriminating between earthquakes and explosions. Detection of the Rayleigh wave from these events is so difficult that further understanding of their mechanism is dependent on an improved monitoring capability with good azimuthal coverage.

14 KEY WORDS

M_s vs m_b
Surface wave excitation
Tectonic stress distribution
Seismicity

Unclassified
Security Classification

M_s vs m_b CHARACTERISTICS OF EARTHQUAKES
IN THE EASTERN HIMALAYAN REGIONS

SEISMIC DATA LABORATORY REPORT NO. 296

AFTAC Project No.:	VELA T/2706
Project Title:	Seismic Data Laboratory
ARPA Order No.:	1714
ARPA Program Code No.:	2F-10
Name of Contractor:	TELEDYNE GEOTECH
Contract No.:	F33657-72-C-0009
Date of Contract:	01 July 1971
Amount of Contract:	$2,490,314
Contract Expiration Date:	30 June 1973
Project Manager:	Robert R. Blandford (703) 836-3882

P. O. Box 334, Alexandria, Virginia 22314

ABSTRACT

The results of a study of M_s vs m_b characteristics of earthquakes in the Eastern Himalayan region are given in this report. It is shown that in this region some earthquakes occur which have M_s vs m_b characteristics similar to explosions, exhibiting low surface wave magnitudes relative to body wave magnitudes, when seen at the reporting stations available to this study. The application of station corrections does not change the general distribution and spread of points in the M_s vs m_b plane, and therefore it is unlikely that station (or path) effects are the source of the anomalies. Focal depths of most of the events studied are shallow or normal and can also be ruled out as causes of low surface wave magnitudes. The geographical distribution of anomalous events correlates with various prominent geological features and probably reflects the distribution of tectonic stress in the area studied. The existence of these anomalous events in certain areas of the world can seriously decrease the effectiveness of the M_s vs m_b criterion in discriminating between earthquakes and explosions. Detection of the Rayleigh wave from these events is so difficult that further understanding of their mechanism is dependent on an improved monitoring capability with good azimuthal coverage.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Cont'd.)

LIST OF FIGURES (Cont'd.)

LIST OF FIGURES (Cont'd.)

INTRODUCTION

This report describes a study of M_s vs m_b characteristics of earthquakes in a limited region comprising the eastern Himalayas, and parts of Assam and Tibet. This study is preliminary and is intended to be continued and expanded in scope.

M_s vs m_b characteristics are generally thought to be one of the most effective seismic discriminants between earthquakes and explosions. Earthquakes, in general, excite long period surface waves much more efficiently than do nuclear explosions. The relative excitation of short-period body waves and long-period surface waves by earthquakes is likely to be determined by the characteristics of the source, especially the stress in the source region (Brune 1968; Wyss and Brune 1968; Wyss 1970a, 1970b; Thatcher 1972; Thatcher and Brune 1971; Hanks 1971.) The location of earthquake regions and their source characteristics are now thought to be determined by the distribution of lithospheric plate boundaries and their relative motion (Isacks, Oliver, and Sykes 1968; LePichon 1968).

It can be expected, therefore, that the source characteristics, in particular, the stress present in the source region will vary considerably, depending on the particular region considered. Recent research has shown that there is a wide variation in the relative amplitude of short-period body waves and long-period surface waves from earthquakes which cannot be explained by differences in propagation paths or radiation patterns

(Thatcher 1972; Thatcher and Brune 1971; Marshall and Basham 1972). Such variations are of considerable interest in the problem of detection and identification of nuclear explosions, since high-stress earthquakes could be mistaken for nuclear explosions. On the other hand, nuclear explosions could be effectively hidden in high-stress regions. From a long range point of view it is also very important to map the distribution of stress, since it contains information about deformational processes currently in progress within the earth.

TECHNICAL DISCUSSION

Data

The region studied is bounded by latitudes 27°N and 34°N and longitudes 92°E and 100°E, and is shown in Figure 1 along with the stations used. Geographically this region covers the eastern-most part of the Himalaya range and part of the north-south trending mountain ranges which continue southward to Burma. Toward the south, part of Assam is included, and in the north a portion of the Tibetan Plateau. The available geological information is not sufficient to describe the region accurately, as would be desirable. (Gansser 1964; Smirnov 1964.) A tectonic map of the region has been published by the Geologic Institute of the Academy of Sciences of the USSR. The Tibetan portion of the map is based on recent Chinese works in the area. The map is reproduced in Figure 2.

Tapes containing NOS epicentral data have been searched for earthquakes occurring within this region between 1960 and 1971. Approximately one-hundred events were found. Data for 67 events was ordered. Most of the remaining events were not ordered either because NOS did not compute a body wave magnitude, or because their magnitude was less than 4.0. The 67 events are listed in Table IA. Coordinates and elevations for the stations used are given in Table IB. The same table also shows the average distances and azimuths from the center of the region studied to all the stations. Eleven of

the 67 events were not used in the analysis, however, due to lack of or poor quality of data. Two additional events were not analyzed because they were mixed with other events. The total 13 events are indicated by daggers in Table IA. Most of the events have shallow or normal focal depths, and are scattered over all parts of the region but there are the following main areas of seismicity: the Himalayan front, the eastern end of the plain of Assam and mountain ranges trending southeast towards Burma, and a region at the junction of the mountain ranges at around 30°N and 95°E which exhibits swarmlike earthquake activity. There is also a concentration of events around 33°N and 93°E. Figure 1b from Yanshin (1966) shows that 30°N 95°E to be close to a major fault which Lynn Sykes (personal communication) suggests may be the India-Asia continental block suture. The rest of the activity is scattered; there are some possible zones of activity and inactivity which cannot be seen clearly because of the paucity of events. As pointed out by Fitch (1970), the region of Tibet and Western China is very complex and the details of regional plate motions have not been worked out yet. The situation is different for the Himalayas and the crustal block of India. The recognition that India is thrust under the Tibetan plateau predates the notion of plate tectonics by many years. The majority of events used in this study were listed by NOS as shallow or normal depth earthquakes. These depths were presumably determined from travel times and pP phases. Only one earthquake has a depth exceeding 100 km, and only a few are deeper than 50 km. Depth, therefore as we shall see in more detail later, cannot be an explanation for the weak surface waves from some of the events.

For all the events, film chips were obtained from the National Ocean Survey for the following stations: Shillong (SHL), New Delhi (NDI), Kabul (KBL), Quetta (QUE), Lahore (LAH), Poona (POO), and Chiang Mai (CHG). These stations are equipped with the standard WWSSN instrumentation. The period of the LP seismograph pendulum was changed during the year 1965 from 30 seconds to 15 seconds. This improved the detection of short period (10-15 second) surface waves which for some small events are the most prominent. Since most events of interest were small in magnitude, it was decided not to order data for more distant stations.

Unfortunately there is not enough data available to establish regional body wave magnitude formula in the areas studied, as was done by Evernden (1967) for the United States. The complexity of this region makes it likely that several different crustal models would be necessary to explain crustal phases at all stations. The coverage of the stations is not sufficient to establish such models. Attempts to find systematic patterns of P phases at various stations and thus separate them from depth phases yielded no conclusive results. Search for pP phases also did not give consistent results.

Computations

Magnitudes were computed for all events in the sample. Short-period body wave magnitudes (m_b) were computed with the conventional Gutenberg formula, in the absence of better body wave magnitude formulas for the region. This undoubtedly contributes to the scatter of m_b values.

To evaluate the network bias in m_b we selected the six out of the original 67 events for which the NOS Earthquake Data Reports show eight or more stations used in the calculation for m_b. For five of the six events we also were able to calculate an m_b value. (Station corrections were calculated and used to remove any station bias with respect to the network, this would not of course remove any network bias.) On the average the NOS magnitudes were larger by 0.2 ± 0.1 m_b (one standard deviation of the mean). This value becomes 0.1 ± 0.15 if stations for which $\Delta > 90°$ or $\Delta < 20°$ are excluded from the NOS magnitude calculations but all other stations reporting magnitudes are included. If our magnitudes were corrected to remove this estimated bias, the earthquakes would look more explosion-like.

Had we used Veith and Clawson's (1972) m_b curve instead of Gutenberg's curve, our network bias would have been reduced by 0.05 m_b.

The surface wave magnitudes were computed by three methods, (1) using the (modified) Prague formula:

$$M_s = \log (A/T) + 1.66 \log\Delta - 0.18 \qquad (1)$$

where A is the maximum peak-to-peak amplitude in millimicrons, (2) the method introduced by Marshall and Basham (1972) for near distances:

$$M_s = \log A + B(T) + C(\Delta) \qquad (2)$$

where A is the maximum zero-to-peak amplitude in millimicrons, with a depth correction given by the equation

$$\bar{M}_s = M_s + .008h_{(km)} \qquad (2a)$$

where h is determined from M_s values taken at different periods, and (3) a formula proposed by von Seggern (1970) for near distances:

$$M_s = \log (A/T) + 1.16 \log\Delta + 0.74 \qquad (3)$$

where A is the maximum peak-to-peak amplitude of the surface wave train (in millimicrons), T is the wave period, and Δ is the epicentral distance in degrees. B(T) and C(Δ) are the period and distance correction factors which are tabulated by Marshall and Basham. In our calculations we used their tables computed for Central Asian surface wave dispersion characteristics. Other equivalent approaches to the regionalization of magnitude calculations with respect to dispersion characteristics were reported by Alewine (1972) and Basham (1971). Of the methods used, only Marshall and Basham's method attempts to correct for depth.

Results

The plots of M_s versus m_b are given in Figures 3, 4 and 5. These magnitudes were computed by averaging the magnitudes at all available stations. Figure 3 shows the surface wave magnitude computed from the Prague formula. Since the stations used are at small epicentral distances for the area studied, this formula tends to give low M_s estimates. Of course if explosions were recorded at the same distance, they also would have low M_s values and the separation would be unaffected. Figures 4 and 5 respectively show the magnitudes computed by the methods

given by Marshall and Basham (1972) with depth corrections, and von Seggern (1970). These formulas were designed to eliminate the dependence of surface wave magnitudes on epicentral distance at short distances ($\Delta < 25°$) and are therefore more applicable to the problem investigated. Trend lines obtained by Marshall and Basham (1972) using data reported by Capon et al. (1967) for M_s vs m_b dependence of earthquakes and explosions in Central Asia are superimposed on all these figures. The magnitudes given are scattered between the two lines, and although most of them are above the explosion lines some of them are fairly close to it. Magnitudes computed by Marshall and Basham's method are the least scattered of all three sets of magnitudes shown.

For all events for which body waves could be detected at any station, surface waves could also be detected at SHL when SHL was operational. In general, for those events for which surface waves could be detected only at SHL, the noise was normal at the other stations, suggesting that the signals truly were small and that the small amplitude at SHL is not the effect only of a radiation pattern.

Table IV shows all the computed magnitudes together with averages.

In order to depict the geographical distribution of the magnitude characteristics, the M_s vs m_b plane in all cases was subdivided into four parts by the lines

$$M_s = m_b - 0.5 \tag{4}$$

$$M_s = m_b - 1.0 \tag{5}$$

$$M_s = m_b - 1.5. \tag{6}$$

In order to avoid cluttering the figures, these lines are not shown on the M_s vs m_b plots, but events from the four parts of the M_s vs m_b planes are plotted with different symbols on a map having equal latitude and longitude intervals. Since the region studied is relatively close to the equator, this does not cause a great amount of areal distortion. The squares on the plot indicate events which are the most explosionlike, and fall below the line defined by equation (6), diamond symbols denote events in the next part of the M_s vs m_b plane above this, crosses denote events falling into the next division above, and finally, events which are above the line defined in equation (4) are denoted by vertical straight lines. Figures 24a through 24e show some examples of seismograms which show the obvious differences in the Rayleigh (and Love) wave excitation of events with similar body wave magnitudes. The event on the left in Figures 24a,b,c show large Rayleigh waves and a large Love wave pulse which is absent in the event on the right. S and Love wave excitation is another matter which should be investigated further. However we may say here that for none of the events represented by a square in Figures 6, 7, and 8 could S waves or Love waves greater than the Rayleigh wave be seen.

Figures 6, 7, and 8 show the plots obtained by using various magnitude formulas. Although the classification of some events changes depending on the magnitude formulas used, all plots show essentially the same geographical distribution pattern. For this type of figure a transparent overlay is included in the back pocket to facilitate geographical orientation.

The most striking feature of the map is the high concentration of explosionlike events in an elongated region centered at about 30°N and 95°E. The earthquakes shown in this region occurred mainly in two sequences of events with body wave magnitudes ranging from 4.5 to 5, one of which occurred in June to August 1968, the other in June to September 1969.

Besides this region there are two clear regions which are also characterized by low M_s values relative to m_b values. One is the frontal region of the Himalayas also described by Marshall and Basham (1972), which shows such events intermingled with normal earthquakes. Another event was reported recently in this region, on October 24, 1971 at 28.2N and 87.2E with m_b (NOS) = 5.1 and $M_s \approx 3$ at LASA, NORSAR and CHG. The other occupies the eastern end of Assam and north-south trending mountain ranges which join the Himalayas and extend south towards Burma. The anomalous region at 30°N and 95°E mentioned above is situated at the eastern end of the high mountains belonging to the Himalayas, where the trend of the mountains turns towards the south. And a deep fault terminates against a Granitoid body. (See Figure 2.)

The observed magnitude characteristics are thus seen to be correlated with geological features, probably reflecting distribution of tectonic stress. Other trends may also be present but they are not consistent on the various plots presented here, and the number of events is not sufficient to obtain a clear pattern. The interior region of Tibet seems to be dominated by shallow earthquakes displaying normal earthquake M_s vs m_b characteristics.

The least squares lines fitted to M_s vs m_b values of earthquakes and explosions in different regions of the earth have had slopes varying between 1.0 and 2.0 with most of the reported values being slightly above 1. Since in the previous figures the M_s vs m_b plane was subdivided with lines having a slope of 1.0, it is necessary to test whether lines with a different slope would change the general picture. Figures 9, 10, and 11 show results obtained when the M_s vs m_b plane was subdivided with the lines

$$M_s = 1.5 m_b - 3.6 \tag{7}$$

$$M_s = 1.5 m_b - 3.1 \tag{8}$$

$$M_s = 1.5 m_b - 2.6. \tag{9}$$

The symbols were designated as before relative to these new lines. The figures show that although the classification of many events changed, the general pattern is the same. That is, explosionlike events falling into the lowermost regions in the M_s vs m_b plane are still concentrated in the same geographical regions. Therefore, it is concluded that the slope of lines for the given data set does not affect the geographical distribution of various types of events.

The average magnitude calculations presented above are influenced by path and station effects. The station effects cause bias due to incompleteness of data, since a varying number of stations are available for individual events. In order to estimate the station effects

the difference between magnitudes at various stations were averaged. Table II shows mean magnitude differences using Quetta (QUE) as a reference station. The standard deviation of the differences from the mean are also shown. Most differences were estimated using about thirty events, except those involving KBL which involved only about 6-7 events. The table shows that SHL, CHG and KBL tend to give considerably higher m_b estimates than the rest of the stations, and the same stations tend to give low M_s values. Therefore earthquakes whose M_s vs m_b values are based on only these stations will appear more explosionlike. M_s corrections for Marshall and Basham's M_s formula are the smallest of the three formulas considered, indicating that this one is the most appropriate for determining M_s for this region. The Prague formula gives too small M_s values at short distances, while von Seggern's formula, based on NTS and Western U.S., tends to overcorrect and gives too high M_s values at short distances.

It was decided to define station corrections in such a way that the mean of the corrections is zero, that is, if all stations in the data group are available, the mean magnitude remains unchanged. This method would make corrections for data with incomplete sets of stations but would not change the bias of the network used. The corrections thus defined for M_s turn out to be fairly small, but some of the corrections for m_b are large. Nevertheless, the bias introduced by the small network is judged to be small, since over all average m_b values are very close to the NOS values, which are typically based on observations at 3-5 teleseismic stations.

Even if the station magnitude differences between KBL and the rest of the stations were disregarded, which could be justified on the basis of too few observations for this station, the average m_b values would not decrease by more than 0.2 magnitude units.

Table V shows the corrected magnitudes. Marshall and Basham's depth correction has been applied by using the NOS reported depth (33 km for normal events) in formula 2a. Measurement at the different Rayleigh wave periods required to estimate h was often impossible because of the pulse-like character of the close-in Rayleigh waves which were the only ones seen for the anomalous events. The corrections reduce the average standard deviation of m_b at individual stations around the event mean values to one-half of the original value and are thus fairly effective. Figures 12, 13, and 16 are the corresponding M_s vs m_b plots.

Since the Marshall and Basham method uses a depth correction the average M_s value determined by this method is relatively high. However, Marshall and Basham (1972) found that application of the depth correction does not cause a shift in the explosions but only in the earthquakes, thereby increasing the separation between the two populations.

Further light is thrown on the effect of depth on M_s vs m_b by Figure 14 where depth corrections have not been applied, but where the events of greater than 60 km depth have been indicated by squares; and the events of unknown depth by filled upright triangles. We see that there

are many shallow events near the explosion population mean. Of course if by using digital recording the spectral depth estimate could be made, and if, as Marshall and Basham assert, the explosion population does not move and if the anomalous events do move up on the M_s vs m_b plot, then Figure 14 would be much like Figure 13 and show better separation. In Figure 15 the Marshall and Basham M_s values are plotted against NOS m_b values. This figure may be compared with Figure 13. In Figure 13 there are no events for which $M_s < m_b - 1.5$, although three are very close. Thus use of NOS m_b values results in events being more anomalous than does use of the SDL m_b values. This is in accord with the bias calculations in the Computations section. As an example of the dangers of using NOS magnitudes, consider the point in the stippled region with $m_b = 5.5$. This m_b value comes from one observation at SHL, a distance of 7.1°. The SDL magnitude, with station corrections, is 4.32. This problem is also present in the work of Landers (1972) where his NOS magnitudes for Tibetan events average 0.25 m_b higher than ours. Because he did not apply depth corrections, his M_s values are on the average 0.23 M_s lower. Thus his results are about 0.5 magnitude units "more anomalous" than ours.

Figures 17, 18, 19, and 20 show the geographical distribution of various types of events as defined by lines of unit slope described above after corrections have been applied. Although classification of individual events changes somewhat, the general pattern did not. Although in Figure 18 no events with observed Rayleigh

waves remain for which $M_s < m_b - 1.5$, three of them are very close to the line.

Station corrections were also computed by the joint magnitude determination (JMD) method (von Seggern, 1972) using only events recorded by at least three stations. The corrections and the slopes and intercepts of the least squares linear fit to points in the log Δ - log A plane are given in Table III. (A is the amplitude of P and Rayleigh waves respectively.) Figures 21a and 21b show plots of log Δ before and after the corrections for P were applied. A visible decrease of scatter results if station corrections are used.

Figures 22a and 22b show a similar plot for Rayleigh wave amplitudes. In this case the decrease of scatter due to the application of corrections is negligible. Figure 23 shows a plot of event factors (F_s for surface waves versus F_b for P waves) which is analogous to the M_s - m_b plots. Triangles denote events whose surface waves were recorded at less than three stations, and these events were excluded for the JMD calculations. Since many of these events have anomalously low surface wave amplitudes, and are therefore of prime interest in this study, their relative event factors were computed subsequently using the exponential decay factor and station corrections derived for the more complete data set. It was found that the relative positions and the scatter of events in the F_s - F_b plane is similar to those in the M_s vs m_b plots, and the geographical distribution of explosion and earthquake type events is unaltered.

It is interesting to speculate about the reasons for the explosionlike character of many events of this region. Besides the high stress at the source it is possible that in the surrounding regions, especially in the thick, high-Q crust of Tibet, the propagation of high-frequency P waves is especially effective, and this could cause the M_s vs m_b values to be more explosion-like. This supposition is contradicted, however by the dominant periods of the P waves, which range between 0.5 - 2 seconds with an average around 1.2 seconds, while P waves in regions of high Q show much higher frequencies. (Isacks et al. 1968.) That the anomalous events are indeed earthquakes and not explosions is indicated by the fact that many arrivals on the short period instruments are dilatations. A study of these and other phases is continuing. It will be difficult however to do a truly definitive study until improved stations and arrays are available in the area.

It must also be noted that the maximum Rayleigh wave amplitudes of many small events occurred at very short periods (8 - 15 seconds). For deep events the dominant period should have been larger. The dependence of surface wave excitation on depth is more critical at short periods and better depth determination could improve M_s values. Whether this would change the character of the anomalous events is not clear at this point.

We should emphasize that the depth corrections used in this report were made using NOS depths, not M_s measurements as done by Marshall and Basham. Thus discrimination could only be aided by this technique. We were unable to

measure a sufficient number of periods for any but a few events to determine a depth independent of NOS. Strictly following Marshall and Basham's procedure would have resulted therefore in almost no depth corrections being applied.

CONCLUSIONS

Some earthquakes in the eastern Himalaya region exhibit anomalously low M_s values relative to m_b values. The geographical distribution of such events shows a pattern which correlates with various geological features, the frontal region of Himalayan mountain ranges and the sudden change of the trend of mountain ranges at 30°N and 95°E. Application of station or depth corrections does not change the general geographical pattern of anomalous events. We tentatively conclude that the anomalous M_s vs m_b character is due to high stresses in the source region. The absolute values of M_s and m_b are such that they resemble explosions detonated in other regions of the earth.

REFERENCES

Aki, K., 1966, Generation and propagation of G waves from the Niigata earthquake of June 16, 1964. 2. Estimation of earthquake moments, released energy and stress strain drop from the G wave spectra, Bull. Earthquake Res. Inst., Tokyo University, v. 44, p. 73-88.

Alwine, R.W., III, 1972, Theoretical and observed distance corrections for Rayleigh-wave magnitude. Seismological Laboratory, California Institute of Technology (unpublished).

Brune, J.N., 1968, Seismic moment, seismicity and rate of slip along major fault zones, J. Geophys. Res., v. 73, p. 777-784.

Evernden, T.F., 1967, Magnitude determination at regional and near regional distances in the United States, Bull. Seismol. Soc. Am., v. 57, p. 591-640.

Fitch, T.J., 1970, Earthquake mechanisms in the Himalayan, Burmese and Andaman regions and continental tectonics in Central Asia, J. Geophys. Res., v. 75, p. 2699-2709.

Gansser, A., 1964, Geology of the Himalayas, Interscience Publishers, John Wiley and Sons, London.

Hanks, T.C., 1971, The Kuril Trench-Hokkaido rise system: large shallow earthquakes and simple models of deformation, Geophys. J. R.A.S., v. 23, p. 173-189.

Isacks, B., Oliver, J. and Sykes, L.R., 1968, Seismology and new global tectonics, J. Geophys. Res., v. 73, p. 5855-5899.

Landers, T., 1972, Some interesting Central Asian events on the M_s:m_b diagram, Geophys. J.R.A.S., v. 31, p. 329-339.

LePichon, X., 1968, Sea floor spreading and continental drift, J. Geophys. Res., v. 73, p. 3661-3697.

Marshall, P.D. and Basham, P.W., 1972, Discrimination between earthquakes and underground explosions employing an improved M_s scale. (Unpublished)

Massachusetts Institute of Technology, Lincoln Laboratory, Semiannual Technical Summary, Seismic discrimination.

Smirnov, L., 1964, An introduction to the geological structure of Europe and Asia.

Thatcher, W. and Brune, T.N., 1971, Seismic study of an ocean ridge earthquake swarm in the Gulf of California, Geophys. J. R.A.S., v. 22, p. 473-450.

Thatcher, W., 1972, Regional variations of seismic source parameters in the Northern Baja California area, J. Geophys. Res., v. 77, p. 1549-1565.

Veith, K.F. and Clawson, G.E., 1972, Magnitude from short-period P data, Bull. Seismol. Soc. Am., v. 62, p. 435-452.

von Seggern, D.H., 1970, Surface wave amplitude- versus distance relation in the western United States, Seismic Data Laboratory Report No. 249, Teledyne Geotech, Alexandria, Virginia.

von Seggern, D.H., 1972, Joint magnitude determination and analysis of variance for explosion magnitude estimates, Seismic Data Laboratory Report No. 286, Teledyne Geotech, Alexandria, Virgnia.

Wyss, M. and Brune, J.N., 1968, Seismic moment, stress, and source dimensions for earthquakes in the California-Nevada region, J. Geophys. Res., v. 73, p. 4681-4694.

Wyss, M., 1970a, Observation and interpretation of tectonic strain release mechanisms, Ph.D. Thesis, California Institute of Technology, Pasadena, California.

Wyss, M., 1970b, Stress estimate for South American shallow and deep earthquakes, J. Geophys. Res., v. 75, p. 1529-1544.

Yanshin, A.L., 1966, Tectonic map of Asian study region.

ACKNOWLEDGEMENTS

Acknowledgements are due to the National Ocean Survey (NOS) Data Center for supplying the data, Mr. D.H. von Seggern for help in computations using his joint magnitude determination method, Drs. R.R. Blandford and E.A. Flinn for valuable comments and suggestions. Mr. Donald J. Reinbold did most of the amplitude readings for the magnitude calculations.

TABLE 1A

List of Events

DATE MO DAY YR	ORIGIN TIME			COORDINATES N.LAT.	E.LONG.	DEPTH KM	MAG	GEOGRAPHICAL REGION
05 26 60	20	5	7.0†	27.0	93.0	*	6.3	Assam India
09 02 60	13	46	5.0†	28.7	98.3	*	5.7	Tibet
09 23 60	5	20	27.0†	27.6	96.2	81	4.1	India-Burma
09 28 60	5	29	30.0†	32.4	95.8	*	5.2	W. China
06 02 63	7	7	57.9	27.8	95.6	143	4.9	Assam, India
07 05 63	7	19	15.8	27.7	92.1	*	4.2	Assam, India
10 08 63	2	51	6.0	28.6	95.1	24	5.4	Assam, India
11 16 63	11	39	37.8	28.1	95.1	37	4.7	Assam, India
01 07 64	4	50	37.0	29.8	98.7	46	5.0	Eastern Tibet
01 27 64	5	29	27.0	29.2	97.2	*	4.9	Southern Tibet
06 10 64	17	55	42.9	31.8	93.1	71	5.0	Tibet
09 01 64	13	22	36.6†	27.2	92.3	*	5.7	India-China Bor Reg
10 06 64	2	54	32.7†	30.3	94.6	*	4.5	Tibet
10 21 64	23	9	18.3†	28.1	93.8	37	5.9	India-China Bor Reg
11 10 64	17	13	3.9	29.8	92.2	69	4.6	Tibet
04 30 65	7	13	23.1	28.3	96.0	*	4.4	India-China Bor Reg
06 04 65	15	56	56.0	31.7	95.2	*	5.0	Tibet
07 31 65	16	36	53.8	32.7	93.2	*	4.9	Tibet
07 31 65	17	7	52.6	32.7	93.1	*	4.7	Tibet
07 31 65	19	1	9.4	32.8	93.0	*	4.4	Tibet
07 31 65	21	44	47.8	32.7	93.1	21	4.9	Tibet
08 01 65	14	14	1.7	32.6	93.6	*	5.5	Tibet
08 01 65	20	9	17.9	32.6	93.3	32	5.3	Tibet
08 02 65	17	49	47.0	32.8	93.3	*	4.8	Tibet
10 06 65	8	3	3.2	29.2	96.1	27	5.4	India-China Bor Reg
12 09 65	20	26	4.0	27.5	92.5	22	5.3	India-China Bor Reg
01 31 66	2	35	5.8	27.9	99.6	*	5.6	Yunnan Prov., China
03 07 66	22	36	3.0†	29.2	98.6	17	5.2	Tibet
03 14 66	4	42	50.0	32.4	97.4	*	4.9	Tibet
05 27 66	14	35	5.0	27.4	96.5	51	4.8	Burma-India Bor Reg
07 05 66	10	1	22.0	27.5	92.4	77	4.8	India-China Bor Reg
09 11 66	15	55	20.0	27.0	95.8	37	5.0	Burma-India Bor Reg
09 26 66	5	10	58.1	27.5	92.6	*	5.6	India-China Bor Reg
09 26 66	6	3	48.0	27.6	92.7	*	4.2	India-China Bor Reg
03 11 67	16	56	48.7	28.4	94.4	7	5.3	India-China Bor Reg
03 14 67	6	58	4.6	28.4	94.3	24	5.9	India-China Bor Reg
07 07 67	22	56	30.8	27.8	92.2	*	4.9	India-China Bor Reg
08 15 67	9	21	2.3	31.1	93.7	*	5.7	Tibet
02 16 68	5	37	54.2	33.7	95.1	*	4.8	Tsinghai Province, China
06 28 68	20	34	55.3	30.1	95.1	44	4.8	Tibet
06 30 68	5	4	10.0	30.2	94.8	42	4.8	Tibet
07 01 68	3	11	10.0	30.3	94.5	28	4.3	Tibet
07 04 68	6	45	58.0	30.3	94.9	*	4.7	Tibet
07 13 68	6	5	54.2	30.3	94.6	*	5.0	Tibet
07 14 68	18	12	41.0	30.3	94.8	22	4.9	Tibet
07 15 68	5	9	5.9	30.3	95.0	22	4.8	Tibet
07 16 68	22	23	7.0	30.3	94.8	40	4.8	Tibet
07 19 68	18	48	59.0†	30.2	94.9	*	4.9	Tibet
07 23 68	20	51	47.9	30.3	94.9	30	4.9	Tibet
07 25 68	3	34	13.0†	30.2	94.8	*	4.8	Tibet
07 26 68	12	44	3.0	29.4	95.0	*	4.9	India-China Bor Reg
08 23 68	12	1	16.5	30.3	94.9	*	4.8	Tibet
08 24 68	14	26	7.4	30.0	95.1	56	4.6	Tibet
08 25 68	17	55	5.3	30.4	94.8	19	4.8	Tibet
08 29 68	19	51	24.6	30.2	95.1	*	5.0	Tibet
09 01 68	5	59	26.6	30.3	94.8	20	5.0	Tibet
09 03 68	17	45	54.1	30.2	94.8	53	4.9	Tibet
09 04 68	1	40	4.0	33.5	97.5	*	4.8	Tsinghai Province, China
09 11 68	3	7	32.0	30.3	94.9	38	4.3	Tibet
09 16 68	17	2	40.0†	28.6	95.7	60	4.7	India-China Bor Reg
06 14 69	3	28	29.6†	31.7	94.6	*	5.3	Tibet
08 15 69	7	15	37.0	30.2	95.0	*	5.2	Tibet
11 24 69	2	1	9.3	30.6	98.9	12	4.6	Tibet
02 08 70	19	7	30.0	31.1	93.5	*	4.5	Tibet
02 19 70	7	10	1.8†	27.4	94.0	18	5.5	Eastern India
05 08 70	11	8	8.4	32.8	95.2	35	4.5	Tibet
06 24 70	0	43	1.9	28.9	95.6	*	4.8	India-China Bor Reg

*Depth constrained to 33 km for NOAA location.
†Event not used in analysis due to lack of or poor quality of data.

24

TABLE IB

Stations Used

STATION	ABBREVIATION	LATITUDE	LONGITUDE	ELEVATION (km)	TO CENTER OF REGION OF INTEREST DISTANCE (km)	AZIMUTH
Shillong, India	SHL	25°34'00.00"N	91°53'00.0"E	1600	590	215
Chiang Mai, Thailand	CHG	18°47'24.0"N	98°58'37.0"E	416	1300	160
New Delhi, India	NDI	28°41'00.0"N	77°13'00.0"E	230	1700	270
Lahore, Pakistan	LAH	31°33'00.0"N	74°20'00.0"E	210	2000	280
Poona, India	POO	18°32'00.0"N	73°51'00.0"E	556	2500	245
Quetta, Pakistan	QUE	30°11'18.0"N	65°57'00.0"E	210	2700	275
Kabul, Afganistan	KBL	34°32'27.0"N	69°02'35.4"E	1920	2500	290

TABLE II

Magnitude Differences Between Stations

$(M_{QUETTA} - M_{STATION})$

Station	m_b		M_s (Prague)		M_s Marshall & Basham		M_s (von Seggern)	
SHL	-.784	±.014	.198	±.014	- .012	±.013	- .175	±.013
CHG	-.603	±.014	.045	±.015	- .001	±.013	- .171	±.016
NDI	-.138	±.014	.045	±.012	- .000	±.011	- .206	±.013
LAH	-.083	±.050	.157	±.017	- .053	±.017	- .258	±.018
POO	-.189	±.013	.303	±.010	- .087	±.010	- .225	±.011
QUE	.000		.000		.000		.000	
KBL	-1.07	±.100	.146	±.080	.254	±.067	.128	±.060

TABLE III

Results of Joint Magnitude Determination (JMD) Calculations

P waves

Slope .247 ± .215 (95% confidence limits)

Intercept 1.537

Corrections

Station	Correction	Number of Events
SHL	.13	30
CHG	-.21	43
NDI	-.03	36
LAH	.33	9
POO	.16	28
QUE	-.17	47
KBL	.94	6

Rayleigh waves

Slope .993 ± .191

Intercept 4.549

Corrections

Station	Correction	Number of Events
SHL	.01	34
CHG	-.01	33
NDI	-.03	30
LAH	.04	20
POO	.14	23
QUE	-.06	36
KBL	-.16	6

Note: Corrections are to be subtracted from the observations (log A/T) corrected for exponential distance dependence.

TABLE IV

Event Magnitudes (Marshall and Basham M_s With Depth Correction Using NOS Depth)

DATE	REGION	TIME HR	TIME MIN	TIME SEC	LOCATION LAT	LOCATION LONG	DEPTH (km)	STATION	DISTANCE (km)	AZIMUTH DEGREES	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von Seggern)
06/02/63	Assam	7	7	57.9	27.8N	95.6E	143	SHL	444.8	237.1	--	3.37	4.91	3.99
								CHG	1055.1	160.2	5.18	3.68	4.92	4.11
								ND1	1804.4	277.4	--	3.32	4.34	3.63
								QUE	2796.2	282.3	4.35	--	--	--
								Average			4.76	3.46	4.72	3.91
07/05/63	Assam	7	19	15.8	27.7N	92.1E	33	ND1	1463.9	277.8	5.15	3.69	3.92	4.05
								QUE	2461.6	282.4	4.49	3.79	3.90	4.04
								Average			4.82	3.74	3.91	4.04
10/08/63	Assam	2	51	6.0	28.6N	95.1E	24	SHL	463.2	224.2	-	3.27	3.77	3.88
								CHG	1155.2	159.2	5.10	4.66	4.84	5.07
								LAH	2025.0	284.4	--	4.03	4.41	4.32
								QUE	2730.5	280.6	4.88	4.19	4.41	4.41
								Average			4.99	4.04	4.36	4.42
11/16/63	Assam	11	39	37.8	28.1N	95.1E	37	SHL	425.2	229.5	--	3.37	3.93	4.00
								CHG	1103.6	158.2	5.28	3.27	3.50	3.69
								ND1	1751.6	276.4	4.15	3.92	4.01	4.25
								QUE	2741.1	281.7	4.45	4.01	4.33	4.23
								Average			4.96	3.64	3.94	4.04
01/07/64	Tibet	4	50	37.0	29.8N	98.7E	46	SHL	819.3	236.7	5.33	--	--	--
								CHG	1219.1	178.6	5.24	4.14	4.41	4.54
								ND1	2088.5	271.9	4.54	4.20	4.40	4.48
								QUE	3053.2	278.8	3.93	4.11	4.39	4.11
								Average			4.76	4.15	4.40	4.38
01/27/64	Tibet	5	29	27.0	29.2N	97.2E	33	SHL	661.9	233.8	--	3.20	3.87	3.74
								CHG	1166.3	170.7	5.15	3.39	3.95	3.80
								ND1	1946.1	273.2	4.04	3.88	3.86	4.18
								QUE	2920.3	279.7	4.20	3.75	3.87	3.75
								Average			4.47	3.56	3.89	3.87
06/10/64	Tibet	17	55	42.9	31.8N	93.1E	71	SHL	700.7	190.1	--	4.23	4.98	4.75
								CHG	1556.4	156.4	4.69	4.29	4.73	4.63
								ND1	1565.4	261.3	4.66	4.41	4.69	4.75
								LAH	1777.3	274.1	3.99	4.40	4.86	4.72
								QUE	2497.5	272.8	4.67	3.27	3.64	3.51
								Average			4.50	4.12	4.38	4.47

TABLE IV (Cont'd.)

DATE	REGION	TIME HR	TIME MIN	TIME SEC	LOCATION LAT	LOCATION LONG	DEPTH (km)	STATION	DISTANCE (km)	AZIMUTH DEGREES	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von Seggern)
11/10/64	Tibet	17	13	3.9	29.8N	92.2E	69	SHL	469.9	183.9	4.06	3.58	4.24	4.19
								NDI	1460.3	268.8	5.41	3.30	4.47	3.66
								POO	2237.4	240.3	4.21	--	--	--
								QUE	2431.2	277.4	4.08	3.62	4.30	3.87
								Average			4.44	3.50	4.34	3.90
04/30/65	India-China	7	13	23.1	28.3N	96.0E	33	SHL	508.5	234.4	--	3.26	4.04	3.85
								CHG	1095.4	163.3	--	3.57	4.04	3.99
								NDI	1837.1	275.8	4.09	3.58	3.79	3.89
								POO	2501.6	249.2	4.16	--	--	--
								QUE	2823.3	281.3	4.09	3.99	4.05	3.99
								Average			4.11	3.60	3.98	3.93
06/04/65	Tibet	15	56	56.0	31.7N	95.2E	33	SHL	752.7	206.3	--	3.40	3.66	3.90
								NDI	1761.2	263.7	--	3.43	3.82	3.75
								POO	2591.0	240.8	4.30	3.83	4.05	4.07
								QUE	2696.7	273.9	4.39	3.74	4.09	3.97
								Average			4.35	3.60	3.91	3.92
07/31/65	Tibet	16	36	53.8	32.7N	93.2E	33	SHL	800.6	189.5	--	4.22	4.51	4.72
								CHG	1644.7	158.1	3.99	4.21	4.39	4.54
								NDI	1592.6	258.0	4.67	3.90	3.92	4.24
								LAH	1782.3	271.0	--	4.28	4.33	4.60
								POO	2489.0	235.6	4.68	4.39	4.42	4.63
								QUE	2503.9	270.6	4.34	4.15	4.29	4.40
								Average			4.42	4.20	4.31	4.52
07/31/65	Tibet	17	7	52.6	32.7N	93.1E	33	SHL	799.1	188.8	--	4.60	4.93	5.02
								CHG	1648.3	157.7	4.56	4.70	4.78	5.03
								NDI	1583.4	257.8	--	4.65	4.81	4.99
								LAH	1772.9	270.9	--	4.75	4.91	5.07
								POO	2481.3	235.5	5.13	4.78	4.82	5.03
								QUE	2494.6	270.6	4.65	4.64	4.87	4.89
								Average			4.78	4.69	4.85	5.02
07/31/65	Tibet	21	44	47.8	32.7N	93.1E	21	SHL	799.1	188.8	5.72	4.77	4.88	5.26
								CHG	1648.3	157.7	4.61	4.59	4.74	4.92
								NDI	1583.4	257.8	4.97	4.43	4.40	4.78
								LAH	1772.9	270.9	--	4.60	4.66	4.92
								POO	2481.3	235.5	5.22	4.68	4.63	4.93
								QUE	2494.6	270.6	5.08	4.39	4.55	4.64
								Average			5.12	4.58	4.64	4.91

TABLE IV (Cont'd.)

DATE	REGION	TIME HR	TIME MIN	TIME SEC	LOCATION LAT	LOCATION LONG	DEPTH (km)	STATION	DISTANCE (km)	AZIMUTH DEGREES	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von Seggern)
07/31/65	Tibet	19	1	9.4	32.8N	93.0E	33	SHL	808.7	188.0	5.56	4.43	4.63	4.92
								CHG	1662.1	157.5	4.32	4.24	4.49	4.58
								NDI	1576.6	257.3	4.79	4.16	4.19	4.51
								LAH	1763.4	270.5	--	4.36	4.52	4.68
								POO	2479.9	235.1	5.01	4.38	4.42	4.63
								QUE	2485.1	270.3	4.71	4.13	4.38	4.38
								Average			4.88	4.29	4.44	4.62
08/01/65	Tibet	14	14	1.7	32.6N	93.6E	33	SHL	796.9	192.5	5.19	3.71	3.95	4.20
								CHG	1620.8	159.3	3.95	3.78	3.75	4.12
								NDI	1627.1	258.8	--	3.88	3.93	4.22
								LAH	1820.1	271.5	--	4.04	4.05	4.36
								POO	2513.9	236.5	--	4.58	4.22	4.82
								QUE	2541.6	271.1	3.98	--	--	--
								Average			4.37	4.00	3.98	4.34
08/01/65	Tibet	20	9	17.9	32.6N	93.3E	32	SHL	791.3	190.4	--	4.52	4.80	5.01
								CHG	2513.5	270.9	4.57	4.56	4.60	4.89
								NDI	2490.5	236.0	5.23	4.66	4.78	5.00
								LAH	1599.5	258.5	--	4.71	4.82	5.02
								POO	1791.9	271.4	4.88	4.98	5.01	5.22
								QUE	1630.9	158.3	4.39	4.52	4.89	4.76
								Average			4.77	4.66	4.82	4.99
08/02/65	Tibet	17	49	47.0	32.8N	93.3E	33	SHL	813.2	190.1	[illegible]	4.12	4.40	4.60
								CHG	1651.5	158.6	--	3.97	4.12	4.30
								NDI	1604.1	257.7	4.18	4.18	4.31	4.52
								LAH	1791.5	270.7	--	4.30	4.45	4.62
								POO	2503.0	255.6	--	4.47	4.58	4.72
								QUE	2513.2	270.5	3.96	3.86	4.52	4.10
								Average			4.37	4.15	4.39	4.48
10/06/65	India-China	8	3	3.2	29.2N	96.1E	27	SHL	579.4	227.0	4.91	3.23	4.23	3.79
								CHG	1188.7	165.1	5.17	3.26	4.08	5.67
								NDI	1839.3	272.8	3.36	3.79	4.07	4.10
								POO	2547.6	247.3	3.99	--	--	--
								QUE	2814.9	279.5	4.52	3.67	4.09	3.67
								Average			4.39	3.49	4.12	3.81
12/09/65	India-China	20	26	4.0	27.5N	92.5E	22	CHG	1169.3	144.2	5.67	3.81	4.33	4.22
								LAH	1814.5	288.7	5.10	4.13	4.17	4.44
								POO	2149.2	246.4	4.54	4.34	4.56	4.72
								QUE	2505.0	282.9	5.15	4.40	4.70	4.65
								Average			5.11	4.19	4.52	4.50

TABLE IV (Cont'd.)

DATE	REGION	TIME HR	TIME MIN	TIME SEC	LOCATION LAT	LOCATION LONG	DEPTH (km)	STATION	DISTANCE (km)	AZIMUTH DEGREES	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von Seggern)
01/31/66	Yunnan	2	35	5.8	27.9N	99.6E	33	SHL	809.5	253.1	5.43	4.22	4.92	4.71
								CHG	1010.3	183.7	--	5.21	5.27	5.65
								NDI	2193.5	277.6	4.96	4.49	4.92	4.76
								POO	2823.4	254.0	5.30	4.49	4.55	4.49
								QUE	3178.5	282.5	5.15	4.52	4.83	4.52
								Average			5.21	4.58	4.90	4.82
03/14/66	Tibet	4	42	50.0	32.4N	97.4E	33	SHL	928.1	216.7	5.62	4.08	4.56	4.54
								CHG	1515.2	173.6	4.92	4.18	4.40	4.53
								NDI	1976.4	263.3	4.98	4.26	4.23	4.55
								LAH	2177.7	273.7	--	4.55	4.49	4.82
								POO	2810.7	242.6	4.89	4.54	4.72	4.54
								QUE	2899.4	273.3	4.58	4.28	4.56	4.28
								Average			5.00	4.51	4.49	4.54
05/27/66	Burma-India	14	35	5.0	27.4N	96.5E	51	SHL	502.8	247.2	--	3.55	4.31	4.14
								CHG	986.0	164.6	5.05	4.02	4.55	4.46
								NDI	1898.6	278.8	4.38	3.91	4.37	4.22
								LAH	2193.9	287.4	--	4.05	4.27	4.32
								POO	2514.8	251.8	4.26	--	--	--
								QUE	2892.6	283.2	4.36	3.92	4.35	3.92
								Average			4.51	3.89	4.37	4.21
07/05/66	India-China	10	1	22.0	27.5N	92.4E	77	SHL	220.2	193.6	--	3.04	4.09	3.81
								NDI	1496.4	278.6	5.29	3.04	3.81	3.40
								QUE	2495.4	282.9	4.66	3.28	3.86	3.55
								Average			4.97	3.12	3.92	3.58
09/26/66	India-China	5	10	58.0	27.6N	92.7E	33	SHL	225.7	198.6	--	4.08	4.76	4.84
								CHG	1163.6	14[illegible].6	6.58	4.80	5.36	5.21
								NDI	1515.9	278.5	5.81	4.93	5.31	5.28
								LAH	1823.8	288.6	5.28	5.03	5.30	5.34
								POO	2158.3	246.6	4.67	5.68	5.80	5.96
								QUE	2514.6	282.9	4.96	5.04	5.27	5.29
								Average			5.46	4.93	5.30	5.32
09/26/66	India-China	6	3	48.0	27.5N	92.6E	0	SHL	239.4	200.0	3.85	3.07	3.62	3.82
								CHG	2521.8	282.7	5.34	--	--	--
								NDI	1524.1	278.1	4.59	--	--	--
								QUE	1167.0	145.3	4.07	--	--	--
								Average			4.46	3.07	3.62	3.82

TABLE IV (Cont'd.)

DATE	REGION	TIME HR	TIME MIN	TIME SEC	LOCATION LAT	LOCATION LONG	DEPTH (km)	STATION	DISTANCE (km)	AZIMUTH DEGREES	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von Seggern)
09/11/66	Burma-India	15	55	20.0	27.0N	95.8E	37	SHL	422.0	248.8	--	2.95	3.78	3.58
								CHG	965.1	159.6	5.08	3.47	4.08	3.92
								NDI	1837.5	280.1	4.95	3.70	4.11	4.02
								POO	2435.1	252.0	--	3.27	3.81	3.52
								QUE	2835.6	284.0	5.19	2.77	3.27	2.77
								Average			5.07	3.23	3.81	3.56
03/11/67	India-China	16	56	48.7	28.4N	94.4E	7	SHL	401.0	219.1	--	4.63	4.97	5.27
								CHG	1161.3	155.4	5.50	4.64	4.94	5.05
								NDI	1679.9	275.2	4.87	4.33	4.48	4.66
								LAH	1964.4	285.1	--	4.24	4.66	4.54
								POO	2360.3	246.9	4.93	4.88	4.88	5.14
								QUE	2667.3	280.9	4.50	4.43	4.47	4.66
								Average			4.95	4.52	4.73	4.89
03/14/67	India-China	6	58	4.6	28.4N	94.3E	24	NDI	1670.2	275.2	5.20	5.43	5.66	5.76
								LAH	1955.0	285.2	--	5.25	5.59	5.55
								POO	2351.3	246.8	5.32	5.34	5.48	5.60
								QUE	2657.7	280.9	4.91	5.24	5.64	5.47
								Average			5.14	5.31	5.59	5.59
07/07/67	India-China	22	56	30.8	27.8N	92.2E	33	SHL	249.3	187.3	--	2.83	3.49	3.58
								NDI	1472.3	277.3	5.42	3.66	3.96	4.02
								LAH	1776.0	287.8	--	3.55	3.56	3.87
								POO	2135.8	245.2	3.70	4.01	3.96	4.29
								QUE	2468.9	282.2	4.27	3.28	3.78	3.52
								Average			4.46	3.46	3.75	3.85
08/15/67	Tibet	9	21	2.3	31.1N	93.7E	33	SHL	638.3	196.6	5.60	4.54	5.08	5.08
								CHG	1462.6	157.5	5.47	4.92	5.16	5.28
								NDI	1612.5	264.6	5.08	4.55	5.30	4.89
								LAH	1841.2	276.6	5.41	4.64	5.01	4.95
								POO	2434.2	239.8	4.98	4.87	5.04	5.12
								QUE	2559.4	274.7	--	4.82	5.08	5.06
								Average			5.31	4.72	5.11	5.06
02/16/68	Tsinghai	5	37	54.2	33.7N	95.1E	33	SHL	953.4	199.9	5.55	4.09	4.49	4.54
								CHG	1696.6	165.9	3.89	4.17	4.47	4.50
								NDI	1789.7	256.7	3.60	3.87	4.37	4.18
								POO	2697.9	236.8	5.02	4.73	4.80	4.95
								QUE	2681.1	269.4	4.37	4.23	4.58	4.46
								Average			4.49	4.22	4.54	4.53

TABLE IV (Cont'd.)

DATE	REGION	TIME HR	TIME MIN	TIME SEC	LOCATION LAT	LOCATION LONG	DEPTH (km)	STATION	DISTANCE (km)	AZIMUTH DEGREES	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von Seggern)
06/28/68	Tibet	20	34	55.3	30.1N	95.1E	44	SHL	593.6	213.0	4.86	3.21	3.74	3.77
								CHG	1311.9	161.7	5.13	2.95	3.50	3.33
								QUE	2704.5	277.3	4.66	2.74	3.30	2.97
								KBL	2494.9	288.2	5.24	2.86	3.45	3.10
								Average			4.97	2.94	3.49	3.29
06/30/68	Tibet	5	4	10.0	30.2N	94.8E	42	SHL	588.0	209.9	4.95	3.11	3.45	3.67
								CHG	1331.7	160.6	5.17	2.66	3.19	3.04
								POO	2479.4	243.4	3.93	3.40	3.70	3.65
								QUE	2674.5	277.0	4.28	3.20	3.41	3.43
								KBL	2464.0	288.0	5.30	--	--	--
								Average			4.72	3.09	3.44	3.45
07/01/68	Tibet	3	11	10.0	30.3N	94.5E	28	SHL	584.0	206.8	4.24	2.79	3.03	3.35
								QUE	2644.5	276.7	4.00	2.79	3.03	3.35
								Average			4.12	2.80	3.03	3.35
07/04/68	Tibet	6	45	58.0	30.3N	94.9E	33	SHL	602.4	210.2	--	3.21	3.49	3.77
								QUE	2682.7	276.9	4.46	--	--	--
								Average			4.46	3.21	3.49	3.77
07/13/68	Tibet	6	5	54.2	30.3N	94.6E	33.	SHL	588.4	207.7	--	3.24	3.59	3.80
								CHG	1348.7	159.9	5.20	3.10	3.37	3.48
								NDI	1693.1	268.3	3.95	--	--	--
								QUE	2654.0	276.8	4.54	--	--	--
								Average			4.56	3.17	3.48	3.64
07/14/68	Tibet	18	12	41.0	30.3N	94.8E	22	SHL	597.6	209.4	5.12	3.30	3.48	3.85
								CHG	1342.2	160.7	5.18	3.09	3.28	3.47
								NDI	1712.3	268.4	4.06	--	--	--
								POO	2484.4	243.2	4.74	--	--	--
								QUE	2673.1	276.8	4.16	4.07	3.93	4.30
								KBL	2460.6	287.8	--	3.57	3.30	3.82
								Average			4.65	3.51	3.50	3.86
07/15/68	Tibet	5	9	5.9	30.3N	95.0E	22	SHL	607.3	211.1	4.75	3.02	3.19	3.57
								CHG	1336.0	161.6	5.02	3.00	3.25	3.38
								NDI	1731.5	268.5	3.77	--	--	--
								QUE	2692.2	276.9	4.30	3.89	3.78	4.11
								Average			4.46	3.30	3.41	3.69

TABLE IV (Cont'd.)

DATE	REGION	TIME HR	TIME MIN	TIME SEC	LOCATION LAT	LOCATION LONG	DEPTH (km)	STATION	DISTANCE (km)	AZIMUTH DEGREES	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von Seggern)
07/16/68	Tibet	22	23	7.0	30.3N	94.8E	40	SHL	597.6	209.4	5.03	3.16	3.48	3.71
								CHG	1342.2	160.7	5.11	--	--	--
								NDI	1712.3	268.4	4.02	--	--	--
								QUE	2673.1	276.8	3.99	--	--	--
								Average			4.54	3.16	3.48	3.71
07/23/68	Tibet	20	51	47.9	30.3N	94.9E	30	SHL	602.4	210.2	--	3.37	3.61	3.93
								CHG	1339.1	161.2	5.25	3.27	3.29	3.65
								NDI	1721.9	268.4	3.98	--	--	--
								QUE	2682.7	276.9	3.99	--	--	--
								Average			4.41	3.32	3.45	3.79
07/26/68	India-China	12	44	3.0	29.4N	95.0E	33	SHL	524.4	216.7	4.63	3.13	3.48	3.71
								CHG	1241.7	271.7	5.09	--	--	--
								POO	2458.6	245.4	4.65	--	--	--
								KBL	2511.0	289.8	5.24	--	--	--
								Average			4.90	3.13	3.48	3.71
08/23/68	Tibet	12	1	16.5	30.3N	94.9E	33	SHL	602.4	210.2	4.80	3.32	3.67	3.88
								CHG	1339.1	161.2	5.00	3.25	3.29	3.63
								Average			4.90	3.25	3.48	3.75
08/24/68	Tibet	14	26	7.4	30.0N	95.1E	56	SHL	584.4	213.6	4.79	2.83	3.37	3.39
								CHG	1301.4	161.6	4.03	--	--	--
								QUE	2706.0	277.6	3.90	--	--	--
								Average			4.24	2.83	3.37	3.40
08/25/68	Tibet	17	55	5.3	30.4N	94.8E	19	SHL	607.3	208.9	4.95	3.15	3.30	3.70
								CHG	1352.7	160.9	4.88	--	--	--
								NDI	1712.6	268.0	3.79	--	--	--
								QUE	2671.9	276.6	3.81	--	--	--
								Average			4.36	3.15	3.30	3.71
08/29/68	Tibet	19	51	24.6	30.2N	95.1E	33	SHL	603.0	212.4	4.83	3.16	3.50	3.71
								CHG	1322.5	161.9	5.15	--	--	--
								NDI	1740.9	268.9	4.04	--	--	--
								QUE	2703.1	277.1	4.06	--	--	--
								Average			4.52	3.16	3.50	3.71

TABLE IV (Cont'd.)

DATE	REGION	TIME HR	TIME MIN	TIME SEC	LOCATION LAT	LOCATION LONG	DEPTH (km)	STATION	DISTANCE (km)	AZIMUTH DEGREES	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von Seggern)
09/01/68	Tibet	5	59	26.6	30.3N	94.8E	20	SHL	597.6	209.4	4.86	3.37	3.62	3.93
								CHG	1342.2	160.7	4.88	--	--	--
								QUE	2673.1	276.8	4.10	--	--	--
								Average			4.61	3.37	3.62	3.93
09/03/68	Tibet	17	45	54.1	30.2N	94.8E	26	SHL	588.0	209.9	5.03	3.16	3.46	3.72
								CHG	1331.7	160.6	5.18	--	--	--
								NDI	1712.0	268.7	3.84	--	--	--
								POO	2479.4	243.4	4.40	--	--	--
								QUE	2674.5	277.0	3.79	--	--	--
								Average			4.45	3.16	3.46	3.72
09/04/68	Tsinghai	1	40	4.0	33.5N	97.5E	33	CHG	1635.6	174.5	4.21	4.02	4.07	4.35
								Average			4.21	4.02	4.07	4.35
09/11/68	Tibet	3	7	32.0	30.3N	94.9E	38	SHL	602.4	210.2	4.76	3.10	3.71	3.66
								CHG	1339.1	161.2	5.11	3.12	3.36	3.50
								POO	2493.0	243.3	4.41	--	--	--
								QUE	2682.7	276.9	3.83	--	--	--
								Average			4.53	3.11	3.54	3.58
08/15/69	Tibet	7	15	37.0	30.2N	95.0E	33	SHL	597.8	211.6	4.96	3.16	3.59	3.72
								CHG	1325.5	161.5	5.16	--	--	--
								LAH	1978.6	279.6	4.55	--	--	--
								QUE	2693.6	277.1	4.64	--	--	--
								Average			4.83	3.16	3.59	3.71
11/24/69	Tibet	2	1	9.3	30.6N	98.9E	12	CHG	1307.5	179.6	5.02	4.09	3.88	4.47
								NDI	2106.5	269.7	4.27	4.21	4.07	4.49
								LAH	2341.4	278.9	4.76	4.10	4.11	4.35
								POO	2856.7	247.9	4.40	4.12	3.88	4.12
								QUE	3059.7	277.4	3.96	3.99	4.27	3.99
								KBL	2826.8	286.8		3.98	3.88	3.98
								Average			4.48	4.08	4.00	4.23
02/08/70	Tibet	19	7	30.0	31.1N	93.5E	33	SHL	633.1	194.9	5.16	3.49	3.97	4.03
								CHG	1470.1	156.7	4.17	3.82	3.99	4.18
								NDI	1593.5	264.5	4.87	3.82	4.02	4.16
								LAH	1822.3	276.5	4.41	4.35	4.50	4.67
								POO	2417.7	239.5	4.81	3.93	3.98	4.19
								QUE	2540.4	274.6	4.28	3.80	3.96	4.04
								KBL	2515.7	286.0	--	3.84	3.90	4.11
								Average			4.62	3.86	4.04	4.19

TABLE IV (Cont'd.)

DATE	REGION	TIME HR	TIME MIN	TIME SEC	LOCATION LAT	LOCATION LONG	DEPTH (km)	STATION	DISTANCE (km)	AZIMUTH DEGREES	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von Seggern)
05/08/70	Tibet	11	8	8.4	32.8N	95.2E	35	SHL	863.7	202.7	5.24	3.28	3.60	3.75
								CHG	1596.5	165.4	4.25	3.22	3.43	3.56
								NDI	1778.6	259.9	3.84	--	--	--
								LAH	1969.4	271.6	3.76	--	--	--
								POO	2652.5	238.7	4.31	--	--	--
								QUE	2691.1	271.4	3.99	3.51	3.66	3.73
								KBL	2426.6	281.8	4.66	3.13	3.32	3.38
								Average			4.29	3.28	3.50	3.61
06/24/70	India-China	0	43	1.9	28.9N	95.6E	33	CHG	1170.5	162.2	5.71	4.21	4.66	4.62
								NDI	1792.6	273.7	4.32	4.33	4.66	4.64
								LAH	2064.4	283.4	4.85	4.18	4.34	4.46
								POO	2489.9	247.4	4.54	4.62	4.60	4.87
								QUE	2772.5	280.9	4.39	4.15	4.62	4.38
								Average			4.76	4.30	4.57	4.59

TABLE V

Event Magnitudes with Station Corrections
(Marshall and Basham M_s Includes Depth
Correction Using NOS Depth)

DATE	REGION	TIME HR	TIME MIN	TIME SEC	LOCATION LAT	LOCATION LONG.	DEPTH (km)	STATION	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von SEGGERN)
06/02/63	Assam	7	7	57.9	27.8N	95.6E	143	SHL	--	3.59	4.88	3.96
								CHG	4.99	3.74	4.91	4.08
								NDI	--	3.29	4.33	3.57
								QUE	4.76	--	--	--
								Average	4.87	3.54	4.70	3.87
07/05/63	Assam	7	19	15.8	27.7N	92.1E	33	NDI	5.42	3.66	3.91	3.99
								QUE	4.90	3.81	3.89	4.18
								Average	5.16	3.73	3.90	4.09
10/08/63	Assam	2	51	6.0	28.6N	95.1E	24	SHL	--	3.49	3.74	3.85
								CHG	4.91	4.72	4.83	5.04
								LAH	--	3.89	4.34	4.21
								QUE	5.29	4.21	4.40	4.55
								Average	5.10	4.08	4.33	4.41
11/16/63	Assam	11	39	37.8	28.1N	95.1E	37	SHL	--	3.59	3.90	3.97
								CHG	5.09	3.33	3.49	3.66
								NDI	5.42	3.89	4.00	4.19
								QUE	4.86	4.03	4.32	4.37
								Average	5.12	3.71	3.93	4.05
01/07/64	Tibet	4	50	37.0	29.8N	98.7E	46	SHL	4.96	--	--	--
								CHG	5.05	4.20	4.39	4.51
								NDI	4.81	4.17	4.38	4.42
								QUE	4.34	4.13	4.37	4.25
								Average	4.79	4.17	4.38	4.39
01/27/64	Tibet	5	29	27.0	29.2N	97.2E	33	SHL	--	3.42	3.84	3.71
								CHG	4.96	3.45	3.93	3.77
								NDI	4.31	3.85	3.85	4.12
								QUE	4.61	3.77	3.86	3.89
								Average	4.63	3.62	3.87	3.87
06/10/64	Tibet	17	55	42.9	31.8N	93.1E	71	SHL	--	4.44	4.96	4.72
								CHG	4.50	4.35	4.71	4.60
								NDI	4.93	4.38	4.67	4.69
								LAH	4.32	4.26	4.79	4.61
								QUE	5.08	3.29	3.62	3.65
								Average	4.71	4.15	4.55	4.45

TABLE V (Cont'd.)

DATE	REGION	TIME HR	TIME MIN	TIME SEC	LOCATION LAT	LOCATION LONG.	DEPTH (km)	STATION	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von SEGGERN)
11/10/64	Tibet	17	13	3.9	29.8N	92.2E	69	SHL	3.69	3.80	4.21	4.16
								NDI	3.68	3.27	4.46	3.60
								POO	4.43	--	--	--
								QUE	4.49	3.64	4.29	4.01
								Average	4.57	3.57	4.32	3.92
04/30/65	India-China	7	13	-3.1	28.3N	96.0E	33	SHL	--	3.48	4.01	3.82
								CHG	--	3.63	4.03	3.96
								NDI	4.36	3.55	3.78	3.83
								POO	4.38	--	--	--
								QUE	4.50	4.01	4.04	4.13
								Average	4.41	3.67	3.96	3.94
06/04/65	Tibet	15	56	56.0	31.7N	95.2E	33	SHL	--	3.62	3.64	3.87
								NDI	--	3.40	3.81	3.69
								POO	4.52	3.54	3.95	3.89
								QUE	4.80	3.76	4.08	4.11
								Average	4.66	3.58	3.87	3.89
07/31/65	Tibet	16	36	53.8	32.7N	93.2E	33	SHL	--	4.43	4.49	4.69
								CHG	3.80	4.27	4.38	4.51
								NDI	4.94	3.87	3.91	4.18
								LAH	--	4.14	4.26	4.49
								POO	4.90	4.10	4.33	4.45
								QUE	4.75	4.17	4.27	4.54
								Average	4.60	4.17	4.27	4.48
07/31/65	Tibet	17	7	52.6	32.7N	93.1E	33	SHL	--	4.81	4.90	5.06
								CHG	4.37	4.76	4.77	5.00
								NDI	--	4.62	4.80	4.93
								LAH	--	4.61	4.84	4.96
								POO	5.35	4.49	4.73	4.85
								QUE	5.06	4.67	4.86	5.03
								Average	4.93	4.66	4.81	4.97
07/31/65	Tibet	21	44	47.8	32.7N	93.1E	21	SHL	5.35	4.98	4.85	5.23
								CHG	4.42	4.65	4.72	4.89
								NDI	5.24	4.40	4.38	4.72
								LAH	--	4.46	4.59	4.81
								POO	5.44	4.39	4.53	4.75
								QUE	5.49	4.41	4.53	4.78
								Average	5.19	4.55	4.60	4.86

TABLE V (Cont'd.)

DATE	REGION	TIME HR	TIME MIN	TIME SEC	LOCATION LAT	LOCATION LONG.	DEPTH (km)	STATION	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von SEGGERN)
07/31/65	Tibet	19	1	9.4	32.8N	93.0E	33	SHL	5.19	4.65	4.61	4.89
								CHG	4.13	4.30	4.48	4.55
								ND1	5.06	4.13	4.17	4.45
								LAH	--	4.22	4.46	4.57
								POO	5.23	4.09	4.33	4.45
								QUE	5.12	4.15	4.37	4.52
								Average	4.95	4.26	4.40	4.57
08/01/65	Tibet	14	14	1.7	32.6N	93.6E	33	SHL	4.82	3.93	3.93	4.17
								CHG	3.76	3.84	3.73	4.09
								ND1	--	3.85	3.92	4.16
								LAH	--	3.90	3.98	4.25
								POO	--	4.29	4.13	4.64
								QUE	4.39	--	--	--
								Average	4.32	3.96	3.94	4.26
08/01/65	Tibet	20	9	17.9	32.6N	93.3E	32	SHL	--	4.73	4.78	4.98
								CHG	4.38	4.62	4.58	4.86
								ND1	5.50	4.63	4.77	4.94
								LAH	--	4.57	4.75	4.91
								POO	5.10	4.69	4.91	5.04
								QUE	4.80	4.54	4.88	4.90
								Average	4.94	4.63	4.78	4.94
08/02/65	Tibet	17	49	47.0	32.8N	93.3E	33	SHL	4.62	4.33	4.37	4.57
								CHG	--	4.03	4.10	4.27
								ND1	4.45	4.15	4.29	4.46
								LAH	--	4.16	4.39	4.51
								POO	--	4.18	4.48	4.54
								QUE	4.37	3.88	4.50	4.24
								Average	4.48	4.12	4.35	4.43
10/06/65	India-China	8	3	3.2	29.2N	96.1E	27	SHL	4.54	3.45	4.20	3.76
								CHG	4.98	3.32	4.06	3.64
								ND1	3.63	3.76	4.05	4.04
								POO	4.21	--	--	--
								QUE	4.93	3.69	4.07	3.81
								Average	4.46	3.55	4.10	3.81
12/09/65	India-China	20	26	4.0	27.5N	92.5E	22	CHG	5.48	3.87	4.32	4.19
								LAH	5.45	3.99	4.41	4.35
								POO	4.76	4.15	4.47	4.54
								QUE	5.56	4.42	4.68	4.79
								Average	5.31	4.11	4.47	4.46

TABLE V (Cont'd.)

DATE	REGION	TIME HR	TIME MIN	TIME SEC	LOCATION LAT	LOCATION LONG.	DEPTH (km)	STATION	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von SEGGERN)
01/31/66	Yunnan	2	35	5.8	27.9N	99.6E	33	SHL	5.06	4.43	4.90	4.68
								CHG	--	5.27	5.26	5.62
								NDI	5.23	4.46	4.90	4.70
								POO	5.32	4.20	4.46	4.31
								QUE	5.56	4.54	4.82	4.66
								Average	5.34	4.58	4.87	4.79
03/14/66	Tibet	4	42	50.0	32.4N	97.4E	33	SHL	5.25	4.29	4.54	4.51
								CHG	4.73	4.24	4.39	4.50
								NDI	5.25	4.23	4.22	4.49
								LAH	--	4.41	4.42	4.71
								POO	5.11	4.25	4.63	4.36
								QUE	4.99	4.30	4.55	4.42
								Average	5.07	4.29	4.46	4.50
05/27/66	Burma-India	14	35	5.0	27.4N	96.5E	51	SHL	--	3.77	4.29	4.11
								CHG	4.86	4.08	4.53	4.43
								NDI	4.65	3.88	4.35	4.16
								LAH	--	3.91	4.20	4.21
								POO	4.48	--	---	--
								QUE	4.77	3.94	4.33	4.06
								Average	4.69	3.92	4.34	4.19
07/05/66	India-China	10	1	22.0	27.5N	92.4E	77	SHL	--	3.26	4.07	3.78
								NDI	5.56	3.01	3.79	3.34
								QUE	5.07	3.30	3.85	3.67
								Average	5.32	3.19	3.90	3.60
09/26/66	India-China	5	10	58.0	27.6N	92.7E	33	SHL	--	4.29	4.74	4.81
								CHG	6.39	4.86	5.34	5.18
								NDI	6.08	4.90	5.29	5.22
								LAH	5.61	4.89	5.24	5.23
								POO	4.89	5.39	5.70	5.78
								QUE	5.37	5.06	5.25	5.43
								Average	5.67	4.90	5.26	5.27
09/26/66	India-China	6	3	48.0	27.5N	92.6E	--	SHL	3.48	3.29	3.59	3.79
								CHG	5.15	--	--	--
								NDI	4.86	--	--	--
								QUE	4.48	--	--	--
								Average	4.49	3.29	3.59	3.79

TABLE V (Cont'd.)

DATE	REGION	TIME HR	TIME MIN	TIME SEC	LOCATION LAT	LOCATION LONG.	DEPTH (km)	STATION	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von SEGGERN)
09/11/66	Burma-India	15	55	20.0	27.0N	95.8E	37	SHL	--	3.17	3.75	3.55
								CHG	4.89	3.53	4.06	3.89
								NDI	5.22	3.67	4.10	3.96
								POO	--	2.98	3.71	3.34
								QUE	5.60	2.79	3.25	2.91
								Average	5.24	3.23	3.77	3.53
03/11/67	India-China	16	56	48.7	28.4N	94.4E	7	SHL	--	4.84	4.95	5.24
								CHG	5.31	4.70	4.92	5.02
								NDI	5.14	4.30	4.47	4.60
								LAH	--	4.10	4.59	4.43
								POO	5.15	4.59	4.79	4.96
								QUE	4.91	4.45	4.45	4.80
								Average	5.13	4.50	4.69	4.84
03/14/67	India-China	6	58	4.6	28.4N	94.3E	24	NDI	5.47	5.40	5.65	5.70
								LAH	--	5.11	5.51	5.44
								POO	5.54	5.05	5.38	5.42
								QUE	5.32	5.26	5.63	5.61
								Average	5.44	5.21	5.54	5.54
07/07/67	India-China	22	56	30.8	27.8N	92.2E	33	SHL	--	3.05	3.47	3.55
								NDI	5.69	3.63	3.94	3.96
								LAH	--	3.41	3.50	3.76
								POO	3.92	3.72	3.86	4.11
								QUE	4.68	3.30	3.77	3.66
								Average	4.76	3.42	3.71	3.81
08/15/67	Tibet	9	21	2.3	31.1N	93.7E	33	SHL	5.23	4.76	5.06	5.05
								CHG	5.28	4.98	5.15	5.25
								NDI	5.35	4.52	5.28	4.83
								LAH	5.74	4.50	4.95	4.84
								POO	5.20	4.58	4.95	4.94
								QUE	--	4.84	5.07	5.20
								Average	5.36	4.70	5.07	5.02
02/16/68	Tsinghai	5	37	54.2	33.7N	95.1E	33	SHL	5.18	4.30	4.47	4.51
								CHG	3.70	4.23	4.46	4.47
								NDI	3.87	3.84	4.35	4.12
								POO	5.24	4.44	4.71	4.77
								QUE	4.78	4.25	4.57	4.60
								Average	4.55	4.21	4.51	4.49

TABLE V (Cont'd.)

DATE	REGION	TIME HR	MIN	SEC	LOCATION LAT	LONG.	DEPTH (km)	STATION	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von SEGGERN)
05/28/68	Tibet	20	34	55.5	30.1N	95.1E	44	SHL	4.49	3.43	3.72	3.74
								CHG	4.94	3.01	3.49	3.30
								QUE	5.07	2.76	3.29	3.11
								KBL	4.58	3.02	3.68	3.37
								Average	4.77	3.05	3.54	3.38
06/30/68	Tibet	5	4	10.0	30.2N	94.8E	42	SHL	4.58	3.33	3.43	3.64
								CHG	4.98	2.72	3.17	3.01
								POO	4.15	3.11	3.61	3.47
								QUE	4.69	3.22	3.39	3.57
								KBL	4.64	--	--	--
								Average	4.61	3.09	3.40	3.42
07/01/68	Tibet	3	11	10.0	30.3N	94.3E	28	SHL	3.87	3.01	3.00	3.32
								QUE	4.41	--	--	--
								Average	4.14	3.01	3.00	3.32
07/04/68	Tibet	6	45	58.0	30.3N	94.9E	33	SHL	--	3.43	3.46	3.74
								QUE	4.87	--	---	--
								Average	4.87	3.43	3.46	3.74
07/13/68	Tibet	6	5	54.2	30.3N	94.6E	33	SHL	--	3.46	3.57	3.77
								CHG	5.01	3.16	3.35	3.45
								NDI	4.22	--	--	--
								QUE	4.95	--	--	--
								Average	4.73	3.31	3.46	3.61
07/14/68	Tibet	18	12	41.0	30.3N	94.8E	22	SHL	4.75	3.52	3.45	3.82
								CHG	4.99	3.15	3.26	3.44
								NDI	4.33	--	--	--
								POO	4.96	--	--	--
								QUE	4.57	4.09	3.91	4.44
								KBL	--	3.73	3.53	4.09
								Average	4.72	3.62	3.54	3.95
07/15/68	Tibet	5	9	5.9	30.3N	95.0E	22	SHL	4.38	3.24	3.17	3.54
								CHG	4.83	3.06	3.23	3.33
								NDI	4.04	--	--	--
								QUE	4.71	3.91	3.76	4.25
								Average	4.49	3.40	3.39	3.72

41

TABLE V (Cont'd.)

DATE	REGION	TIME HR	TIME MIN	TIME SEC	LOCATION LAT	LOCATION LONG.	DEPTH (km)	STATION	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von SEGGERN)
07/16/68	Tibet	22	25	7.0	30.3N	94.8E	40	SHL	4.66	3.38	3.45	3.68
								CHG	4.92	--	--	--
								NDI	4.29	--	--	--
								QUE	4.40	--	--	--
								Average	4.57	3.38	3.45	3.68
07/23/68	Tibet	20	51	47.9	30.3N	94.9E	30	SHL	--	3.59	3.58	3.90
								CHG	5.06	3.33	3.27	3.62
								NDI	4.25	--	--	--
								QUE	4.40	--	--	--
								Average	4.57	3.46	3.43	3.76
07/26/68	India-China	12	44	3.0	29.4N	95.0E	33	SHL	4.26	3.35	3.45	3.68
								CHG	4.90	--	--	--
								POO	4.87	--	--	--
								KBL	4.58	--	--	--
								Average	4.65	3.35	3.45	3.68
08/23/68	Tibet	12	1	16.5	30.3N	94.9E	33	SHL	4.43	3.54	3.64	3.85
								CHG	4.81	3.31	3.28	3.60
								Average	4.62	3.42	3.46	3.73
08/24/68	Tibet	14	26	7.4	30.0N	95.1E	56	SHL	4.42	3.05	3.35	3.36
								CHG	3.84	--	--	--
								QUE	4.31	--	--	--
								Average	4.19	3.05	3.35	3.36
08/25/68	Tibet	17	55	5.3	30.4N	94.8E	19	SHL	4.58	3.37	3.28	3.67
								CHG	4.69	--	--	--
								NDI	4.06	--	--	--
								QUE	4.22	--	--	--
								Average	4.39	3.37	3.28	3.67
08/29/68	Tibet	19	51	24.6	30.2N	95.1E	33	SHL	4.46	3.38	3.48	3.68
								CHG	4.96	--	--	--
								NDI	4.31	--	--	--
								QUE	4.47	--	--	--
								Average	4.55	3.38	3.48	3.68

TABLE V (Cont'd.)

DATE	REGION	TIME HR	MIN	SEC	LOCATION LAT	LONG.	DEPTH (km)	STATION	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von SEGGERN)
09/01/68	Tibet	5	59	26.6	30.3N	94.8E	20	SHL	4.49	3.59	3.59	3.90
								CHG	4.69	--	--	--
								QUE	4.51	--	--	--
								Average	4.56	3.59	3.59	3.90
09/03/68	Tibet	17	45	54.1	30.2N	94.8E	26	SHL	4.66	3.38	3.43	3.69
								CHG	4.99	--	--	--
								NDI	4.11	--	--	--
								POO	4.62	--	--	--
								QUE	4.20	--	--	--
								Average	4.52	3.38	3.43	3.69
09/04/68	Tsinghai	1	40	4.0	33.5N	97.5E	33	CHG	4.02	4.08	4.05	4.32
								Average	4.02	4.08	4.05	4.32
09/11/68	Tibet	3	7	32.0	30.3N	94.9E	38	SHL	4.39	3.32	3.69	3.63
								CHG	4.92	3.18	3.35	3.47
								POO	4.63	--	--	--
								QUE	4.24	--	--	--
								Average	4.54	3.25	3.52	3.55
08/15/69	Tibet	7	15	37.0	30.2N	95.9E	33	SHL	4.59	3.38	3.57	3.69
								CHG	4.97	--	--	--
								LAH	4.88	--	--	--
								QUE	5.05	--	--	--
								Average	4.87	3.38	3.57	3.69
11/24/69	Tibet	2	1	9.3	30.6N	98.9E	12	CHG	4.83	4.15	3.79	4.44
								NDI	4.54	4.18	4.05	4.43
								LAH	5.09	3.96	4.04	4.24
								POO	4.62	3.83	3.78	3.94
								QUE	4.37	4.01	4.25	4.13
								Average	4.69	4.05	4.00	4.24
02/08/70	Tibet	19	7	30.0	31.1N	93.5E	33	SHL	4.79	3.71	3.95	4.00
								CHG	3.98	3.88	3.97	4.15
								NDI	5.14	3.79	4.01	4.10
								LAH	4.74	4.21	4.43	4.56
								POO	5.03	3.64	3.89	4.01
								QUE	4.69	3.82	3.94	4.18
								Average	4.73	3.86	4.05	4.20

TABLE V (Cont'd.)

DATE	REGION	TIME HR	TIME MIN	TIME SEC	LOCATION LAT	LOCATION LONG.	DEPTH (km)	STATION	m_b	M_s (PRAGUE)	M_s (MARSHALL & BASHAM)	M_s (von SEGGERN)
05/08/70	Tibet	11	8	8.4	32.8N	95.2E	35	SHL	4.87	3.50	3.57	3.72
								CHG	4.06	3.28	3.41	3.53
								NDI	4.11	--	--	--
								LAH	4.09	--	--	--
								POO	4.53	--	--	--
								QUE	4.40	3.53	3.65	3.87
								KBL	4.00	3.29	3.56	3.65
								Average	4.29	3.40	3.55	3.69
06/24/70	India-China	1	43	1.9	28.9N	95.6E	33	CHG	5.52	4.27	4.65	4.59
								NDI	4.59	4.30	4.65	4.58
								LAH	5.18	4.04	4.28	4.35
								POO	4.76	4.33	4.50	4.69
								QUE	4.80	4.17	4.60	4.52
								Average	4.97	4.22	4.53	4.55

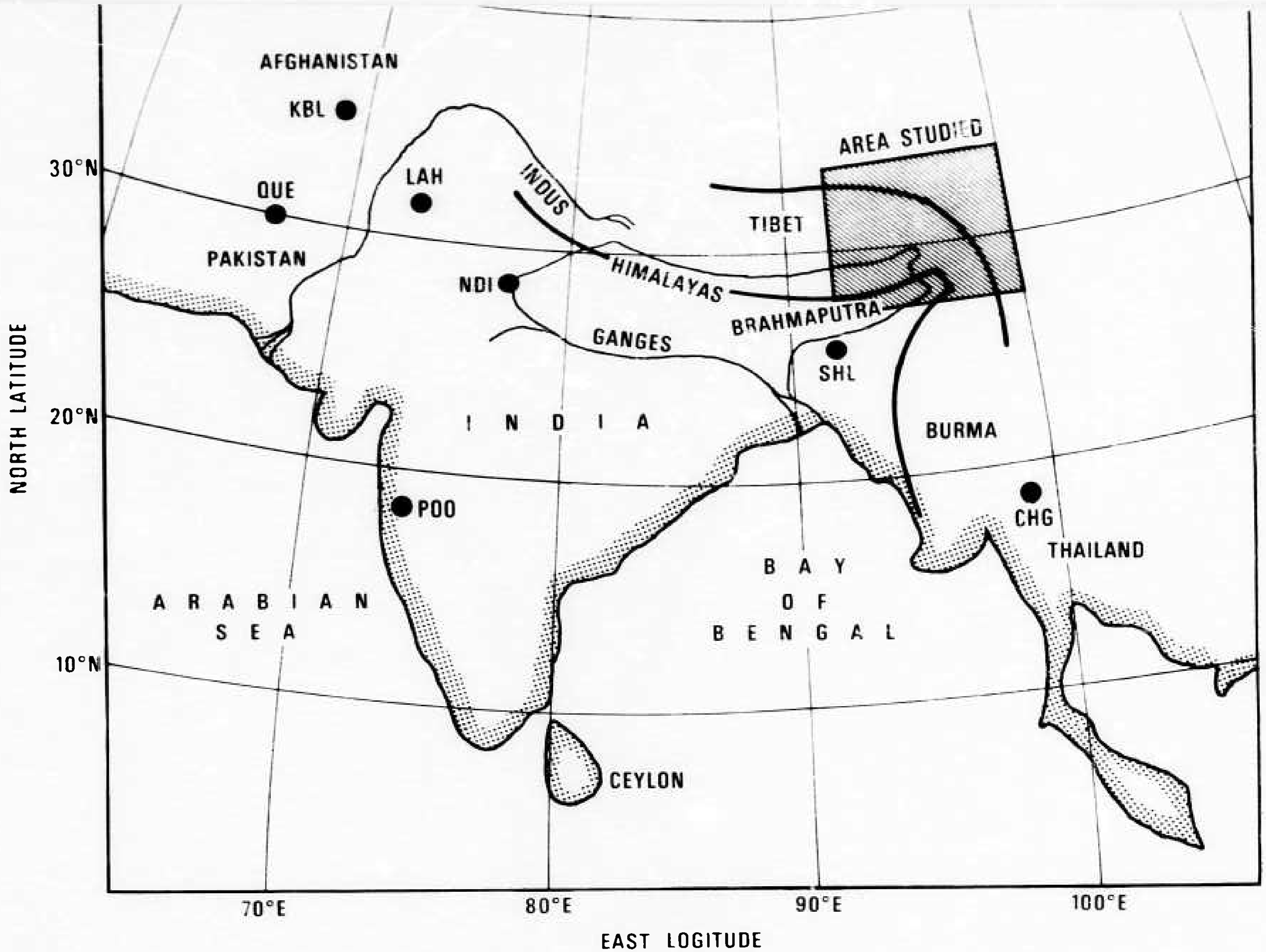


Figure 1. Map of the Eastern Himalayan region including the area studied.

+ Late orogenic (Granitoids)

Main deep faults (Hypothetical)

Normal Faults

Thrusts

Figure 2. Tectonic map of area studied.

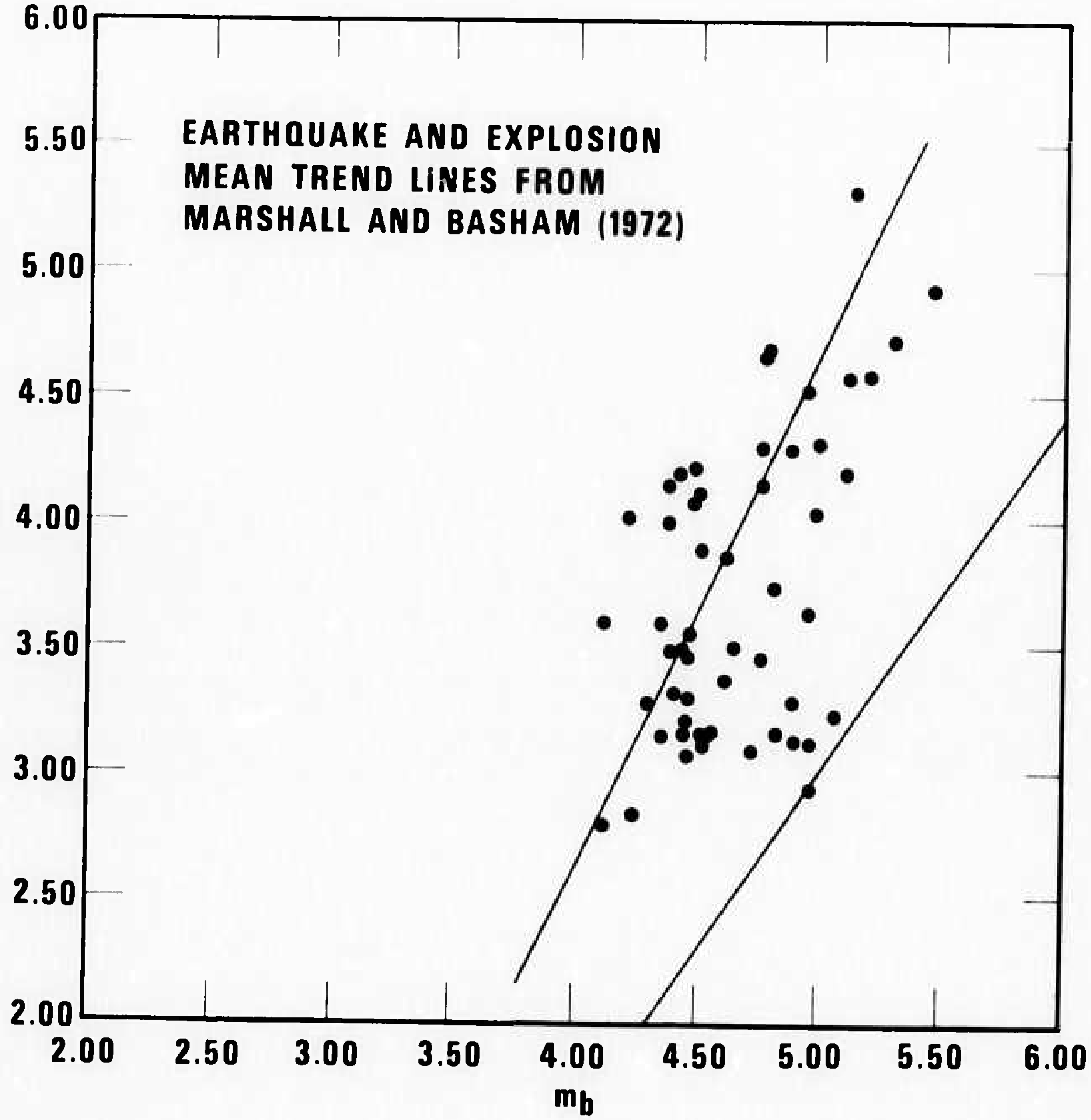


Figure 3. M_S vs m_b values averaged over the station network used. M_S was determined by the "Prague" formula

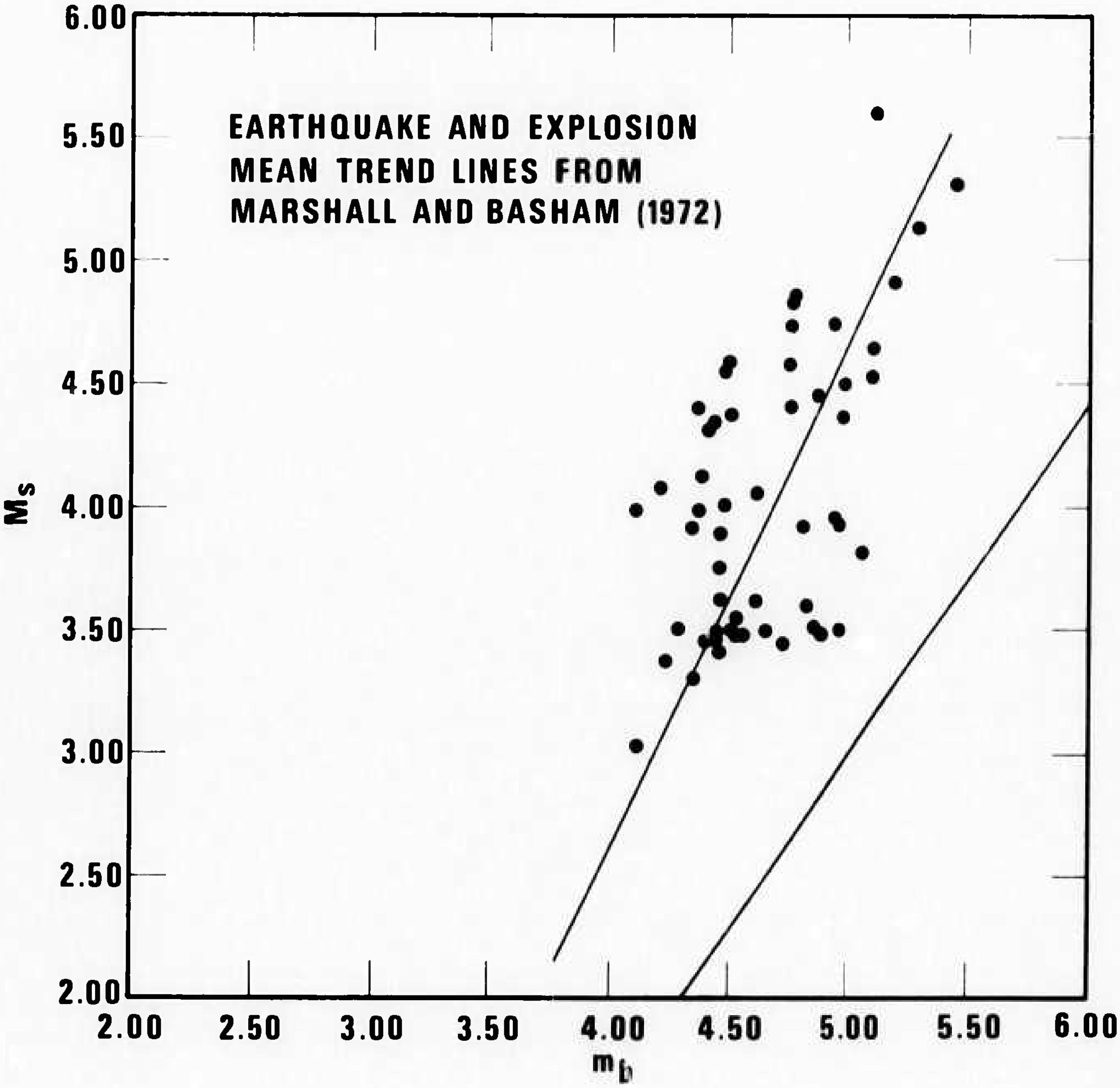


Figure 1. M_s vs m_b values averaged over the station network used. M_s was determined by Marshall and Basham's method with depth corrections using NOS depth.

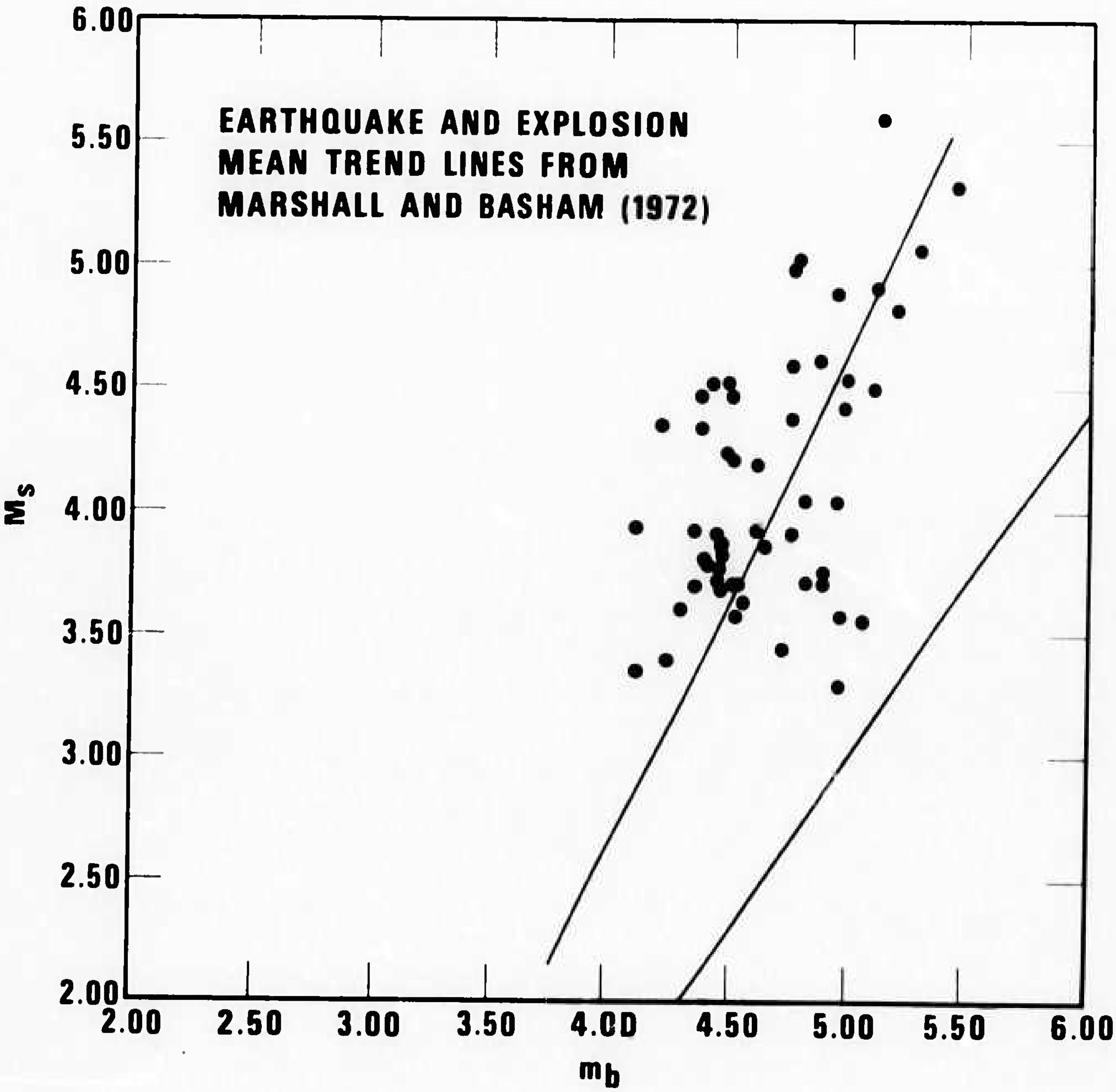


Figure 5. M_s vs m_b values averaged over the station network used. M_s was determined by von Seggern's formula.

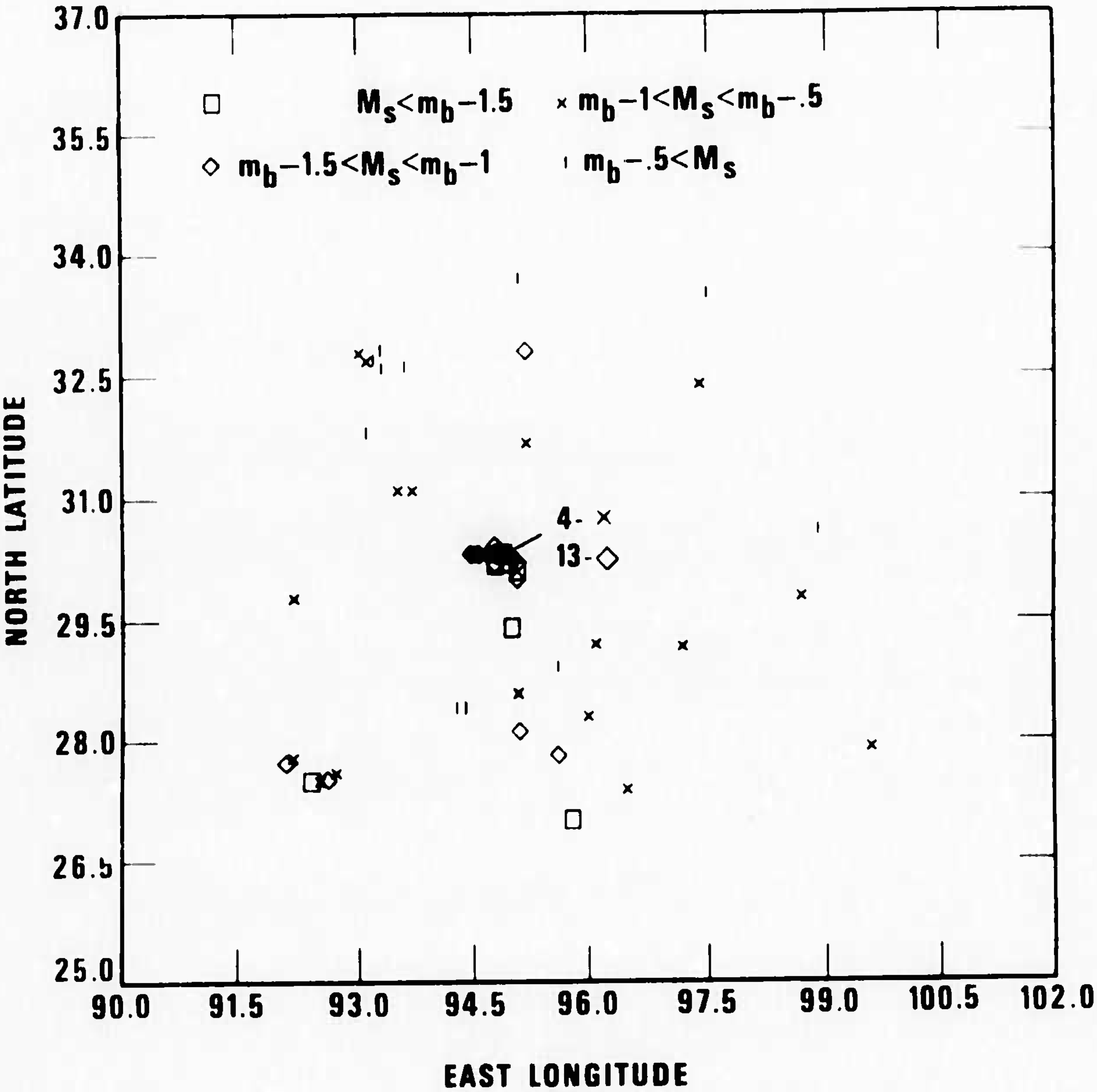


Figure 6. Geographical distribution of various M_s vs m_b types. Definition of types is determined by equations 4, 5, and 6 in text. Prague formula was used for M_s.

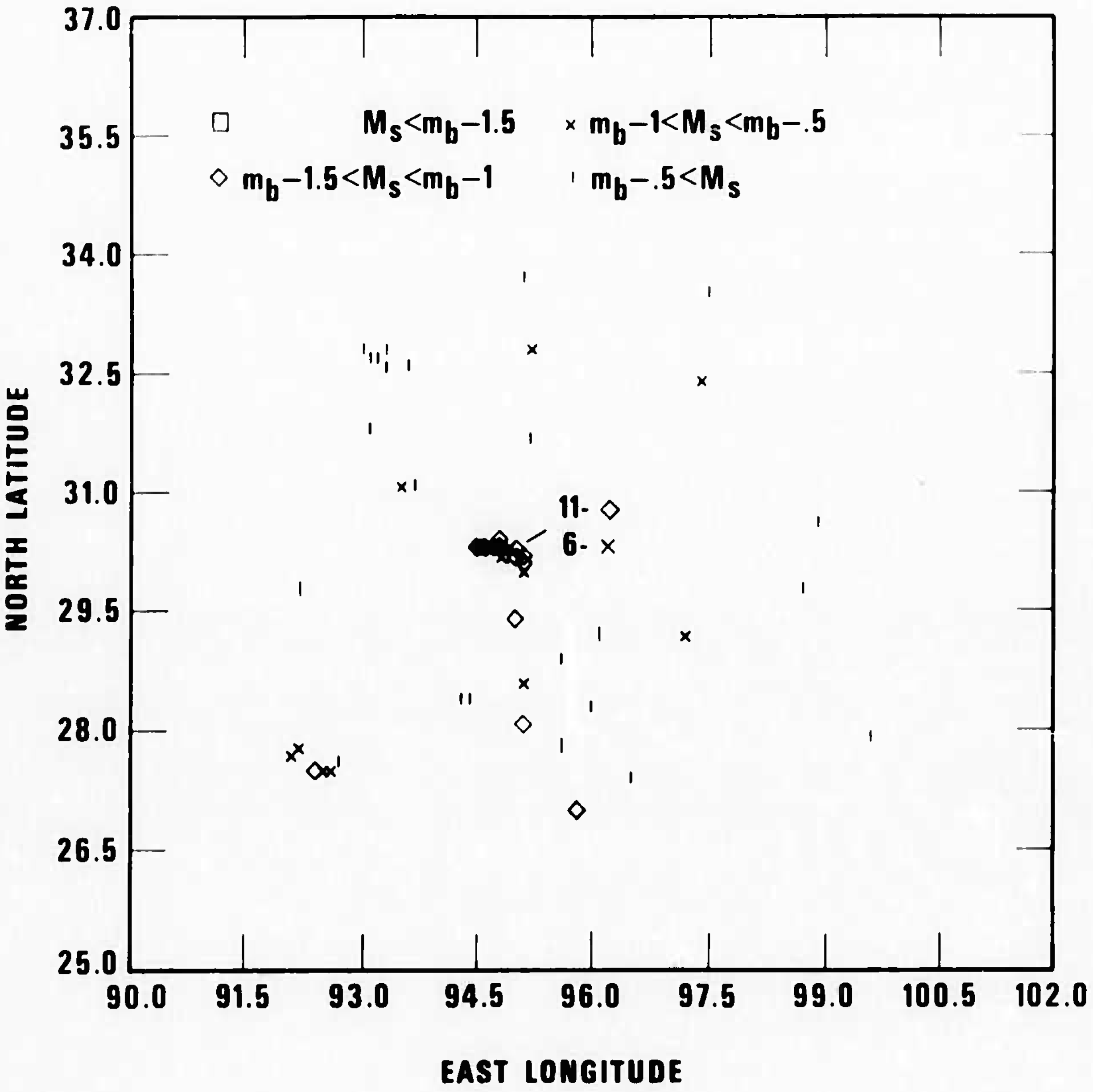


Figure 7. Geographical distribution of various M_s vs m_b types. Definition of types is determined by equations 4, 5, and 6 in text. Marshall and Basham method was used for M_s.

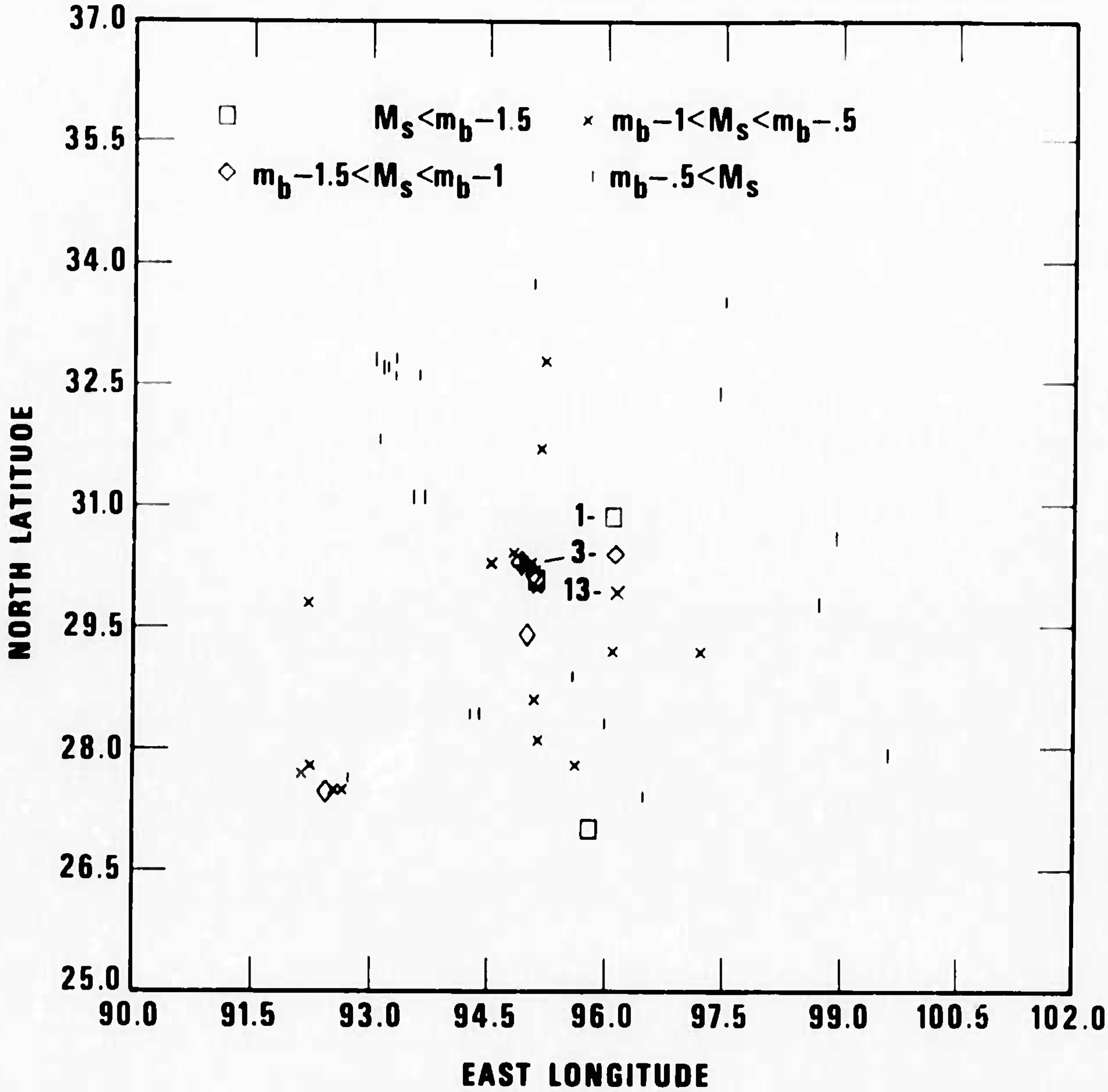


Figure 8. Geographical distribution of various M_s vs m_b types. Definition of types is determined by equations 4, 5, and 6 in text. Von Seggern's formula was used for M_s.

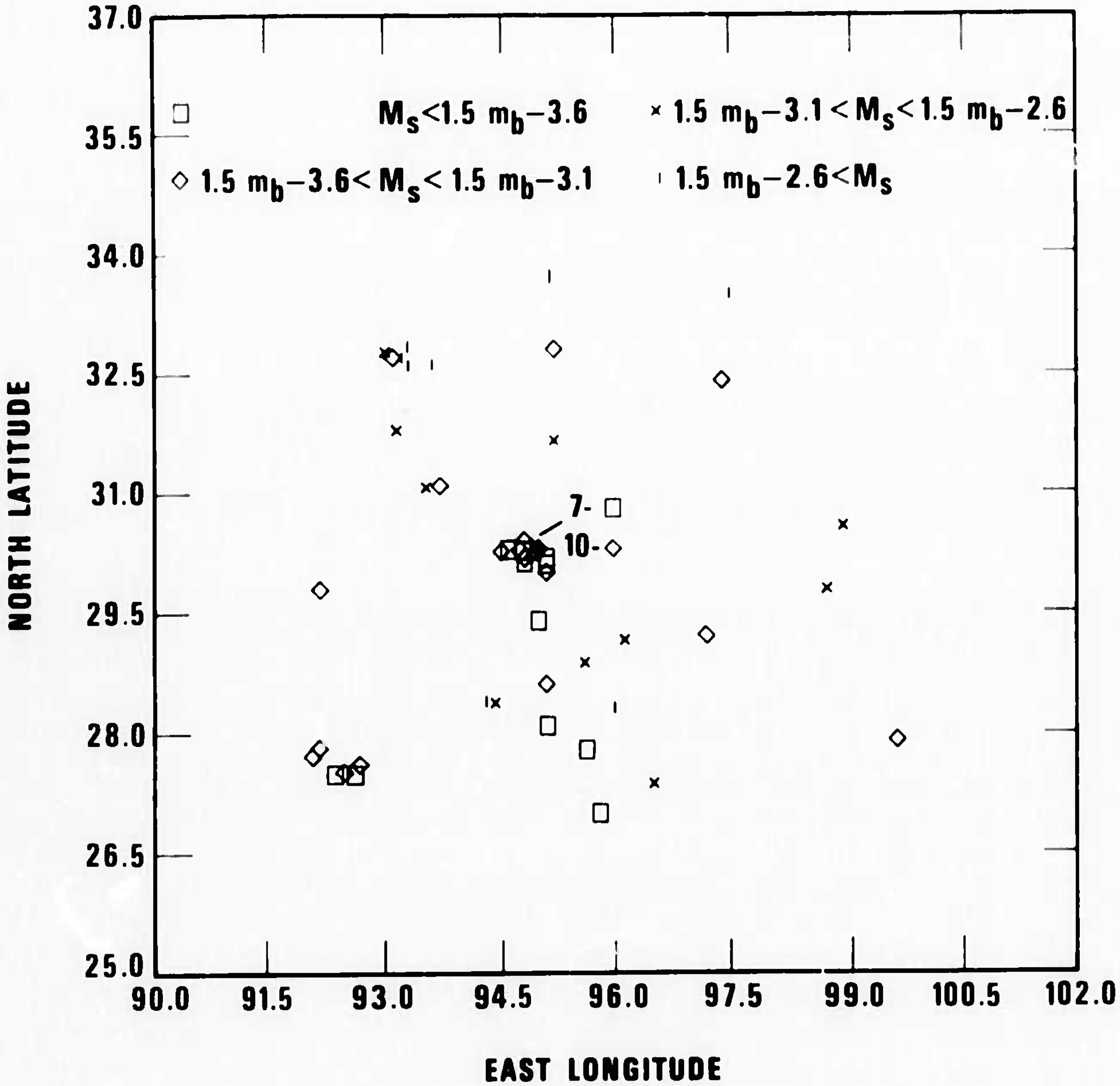


Figure 9. Geographical distribution of various M_s vs m_b types. Definition of type is determined by equations 7, 8, and 9 in text. Prague formula was used for M_s.

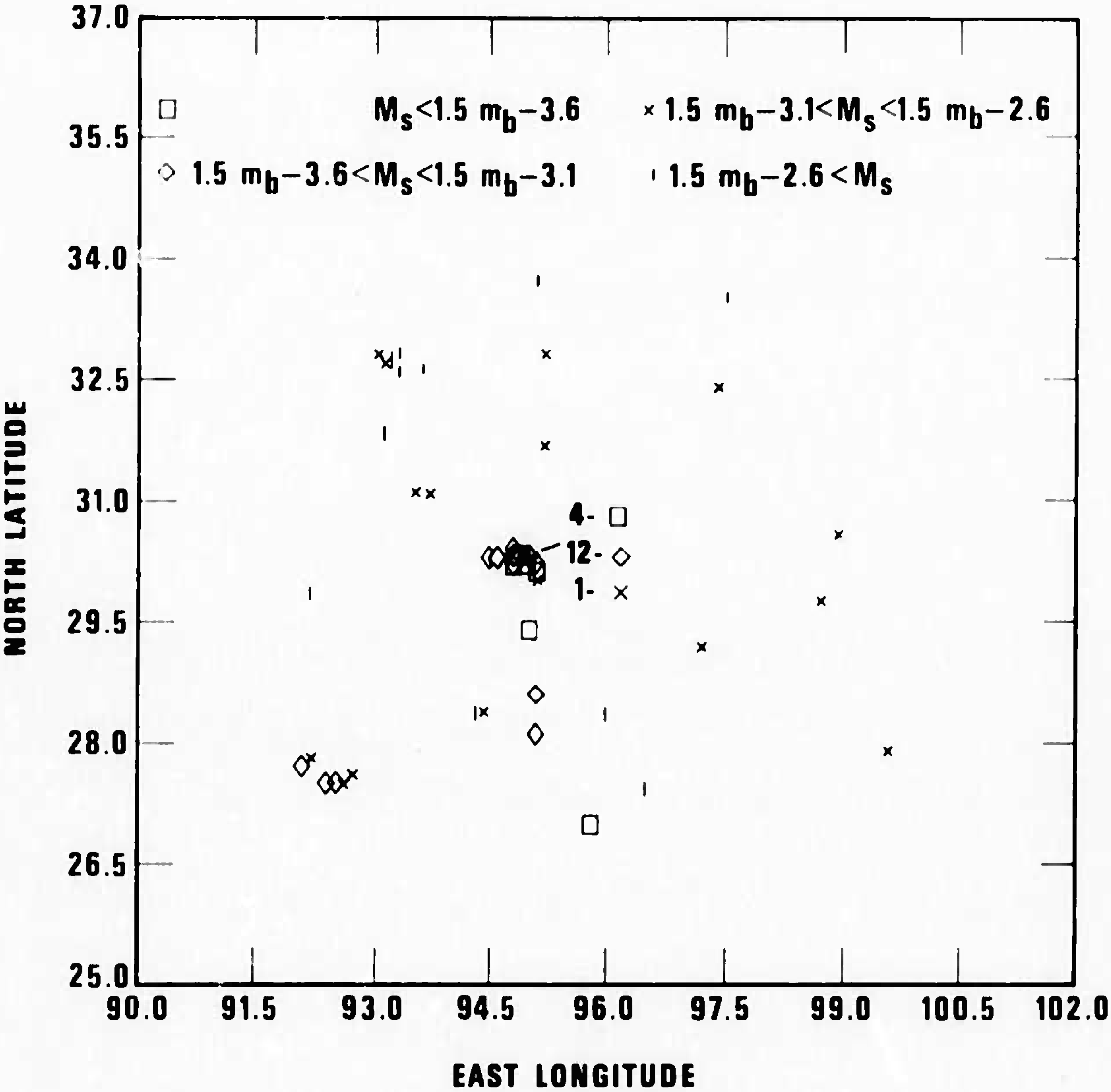


Figure 10. Geographical distribution of various M_s vs m_b types. Definition of type is determined by equations 7, 8, and 9 in text. Marshall and Basham method used for M_s.

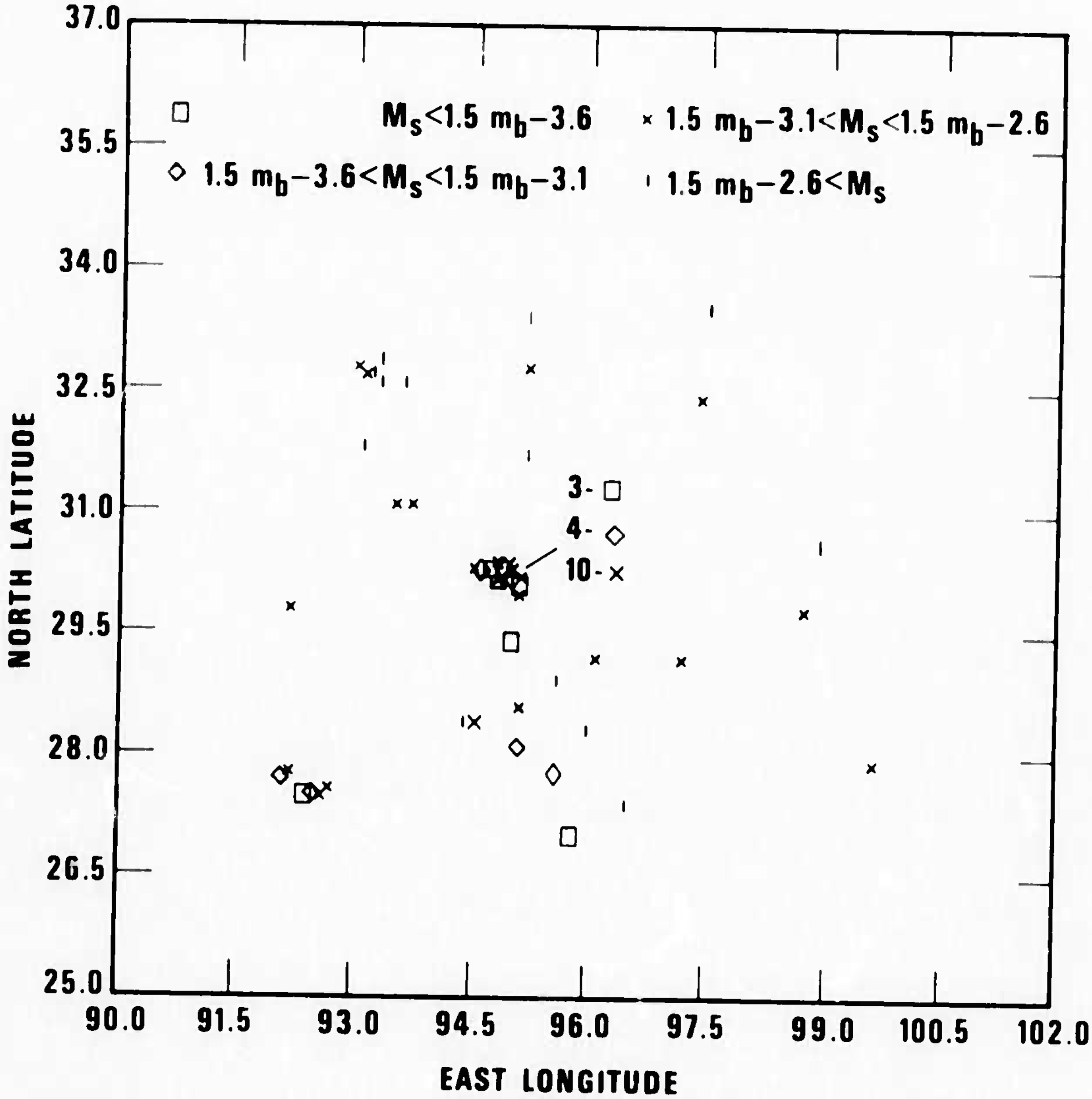


Figure 11. Geographical distribution of various M_s vs m_b types. Definition of type is determined by equations 7, 8, and 9 in text. Von Seggern's formulas was used for M_s.

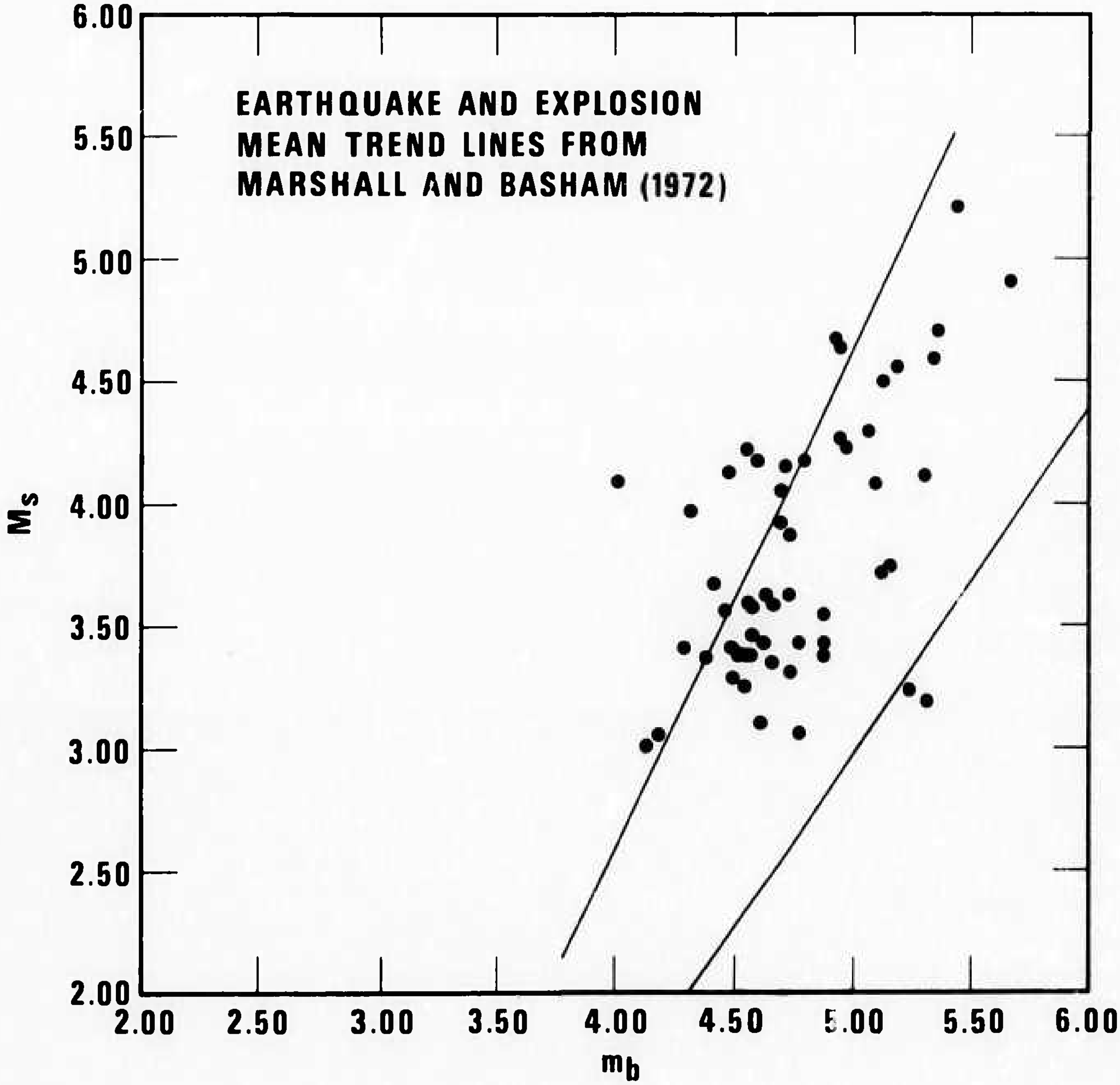


Figure 12. M_s vs m_b values corrected for mean station magnitude differences prior to averaging. Prague formula was used for M_s.

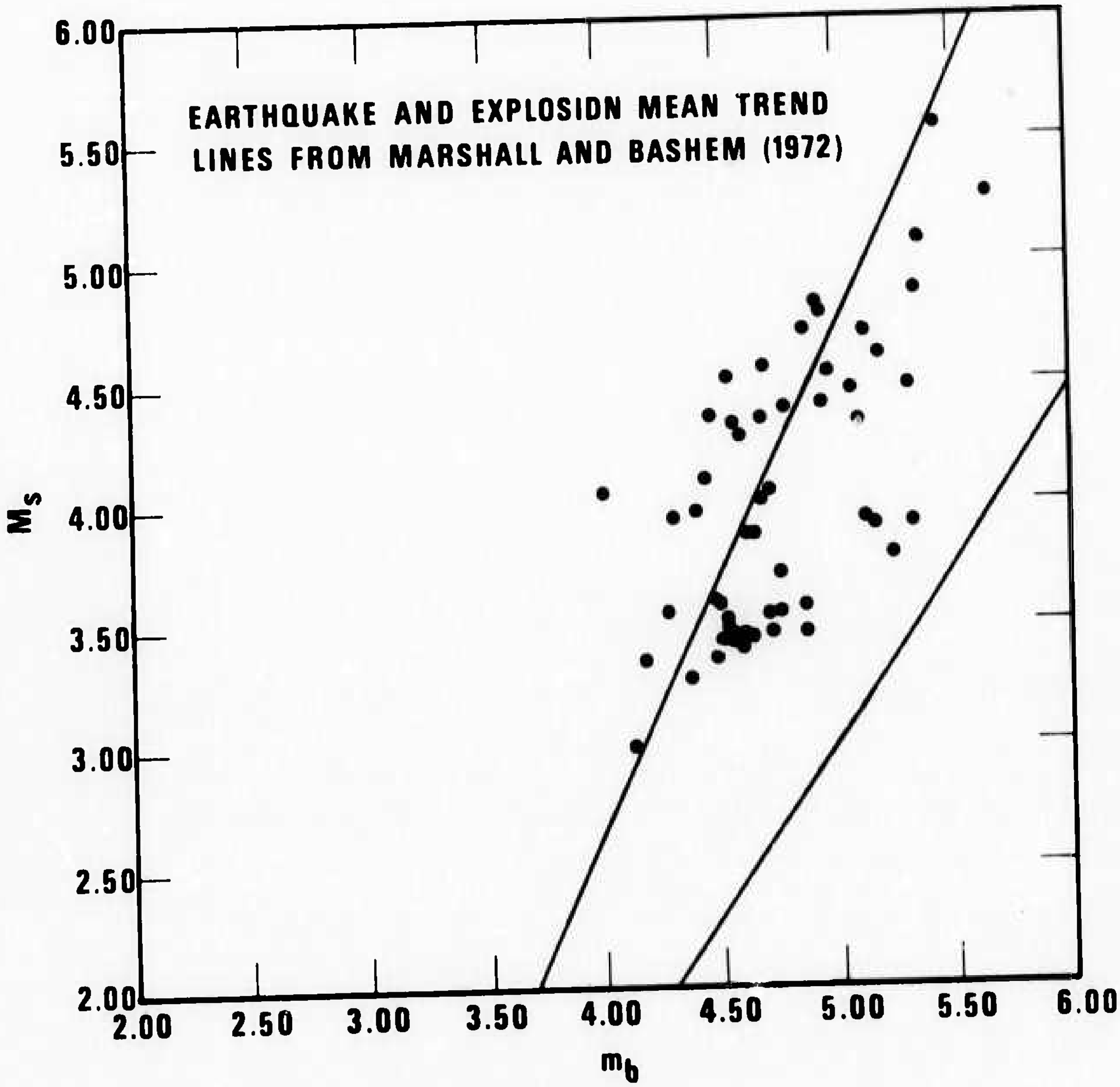


Figure 13. M_s vs m_b values corrected for mean station magnitude differences prior to averaging. Marshall and Basham's method with depth corrections was used for M_s.

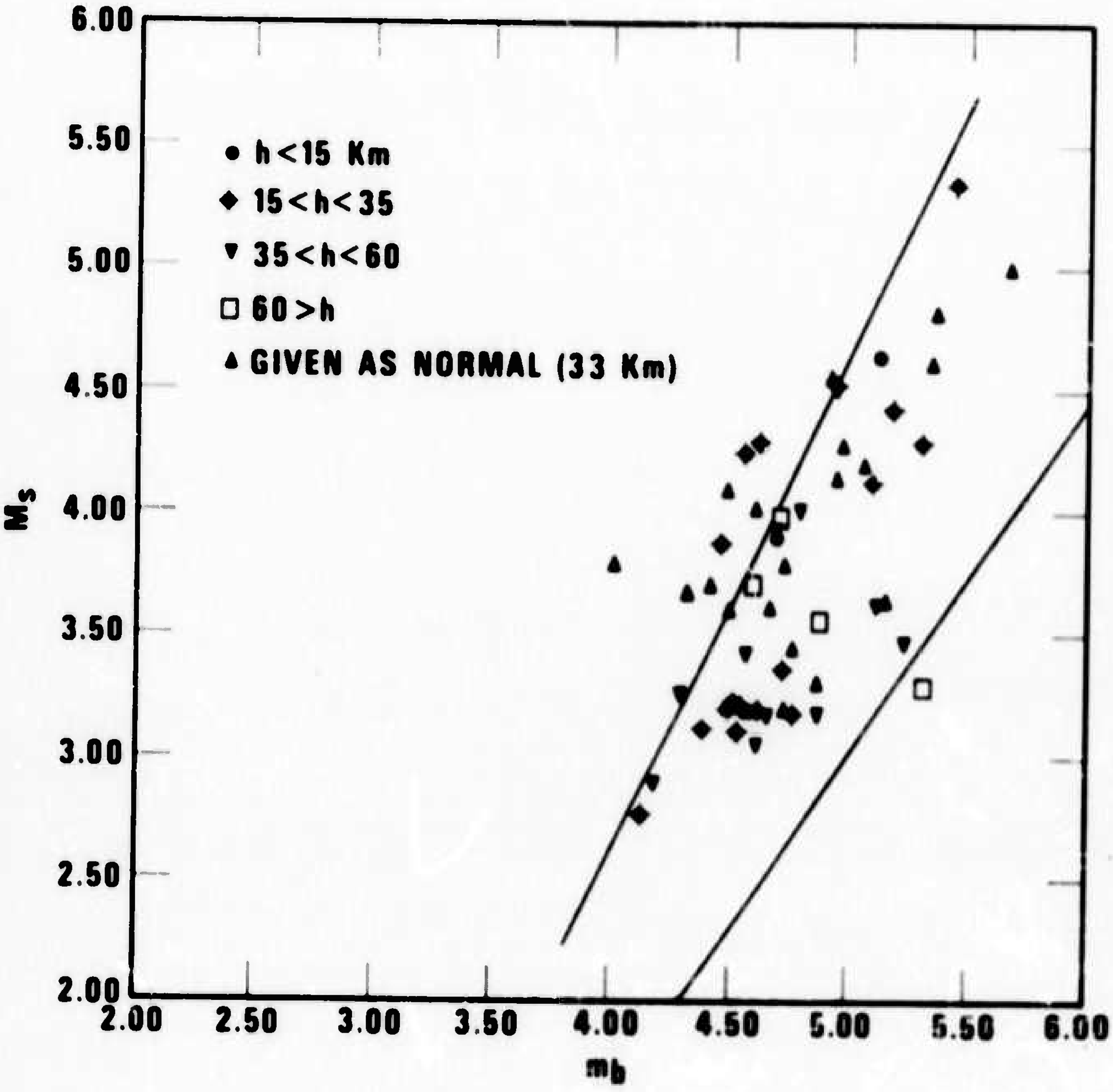


Figure 18. M_s vs m_b values corrected for mean station magnitude differences prior to averaging. Marshall and Basham method was used for M_s. No depth corrections were applied.

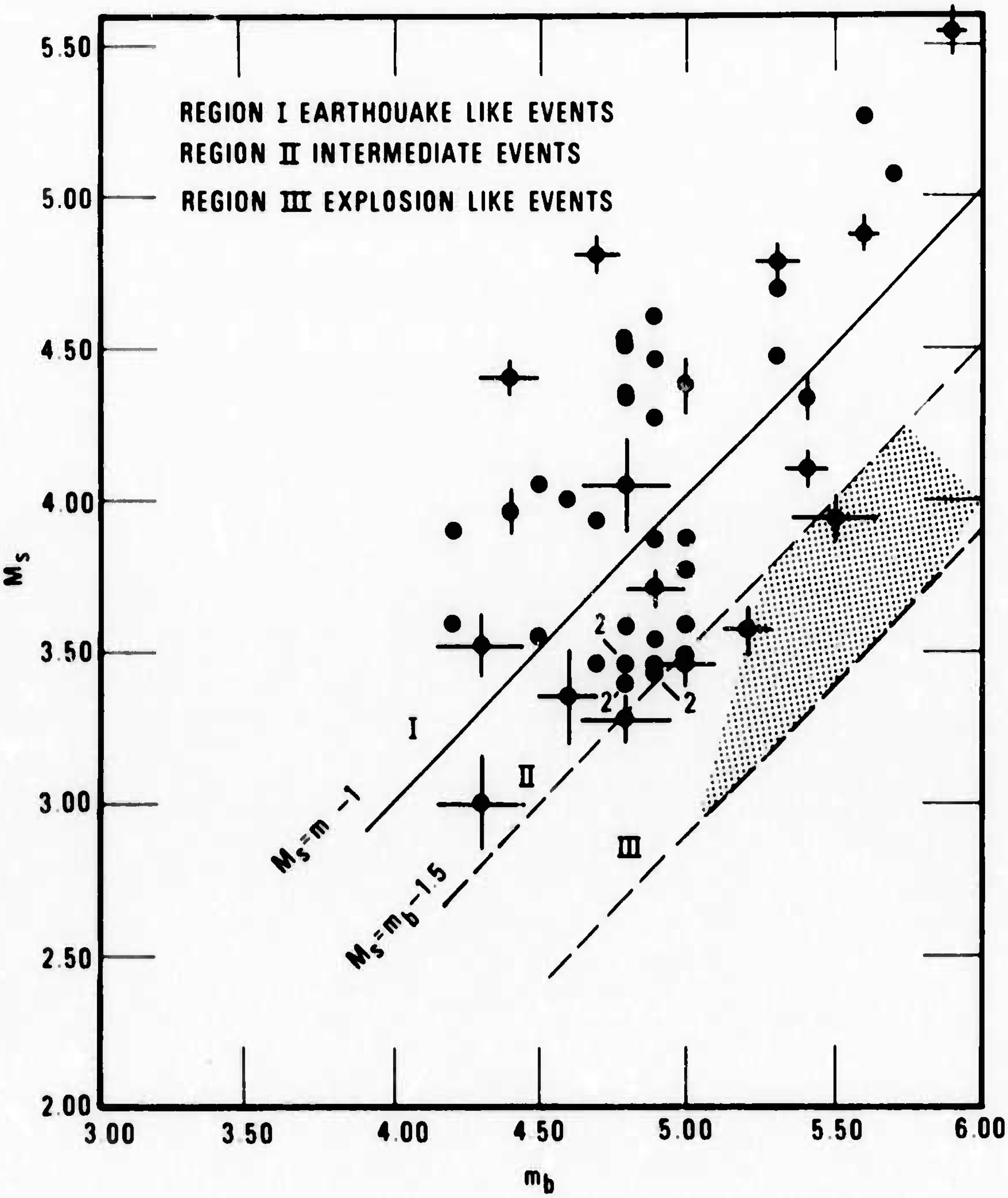


Figure 15. M_s computed with the method of Marshall and Basham (with depth corrections) plotted with NOS m_b values. Stippled region shows area occupied by explosions in the paper by Marshall and Basham (1972). Bars give one standard deviation of the mean for selected events. ($\pm\ \sigma/2$)

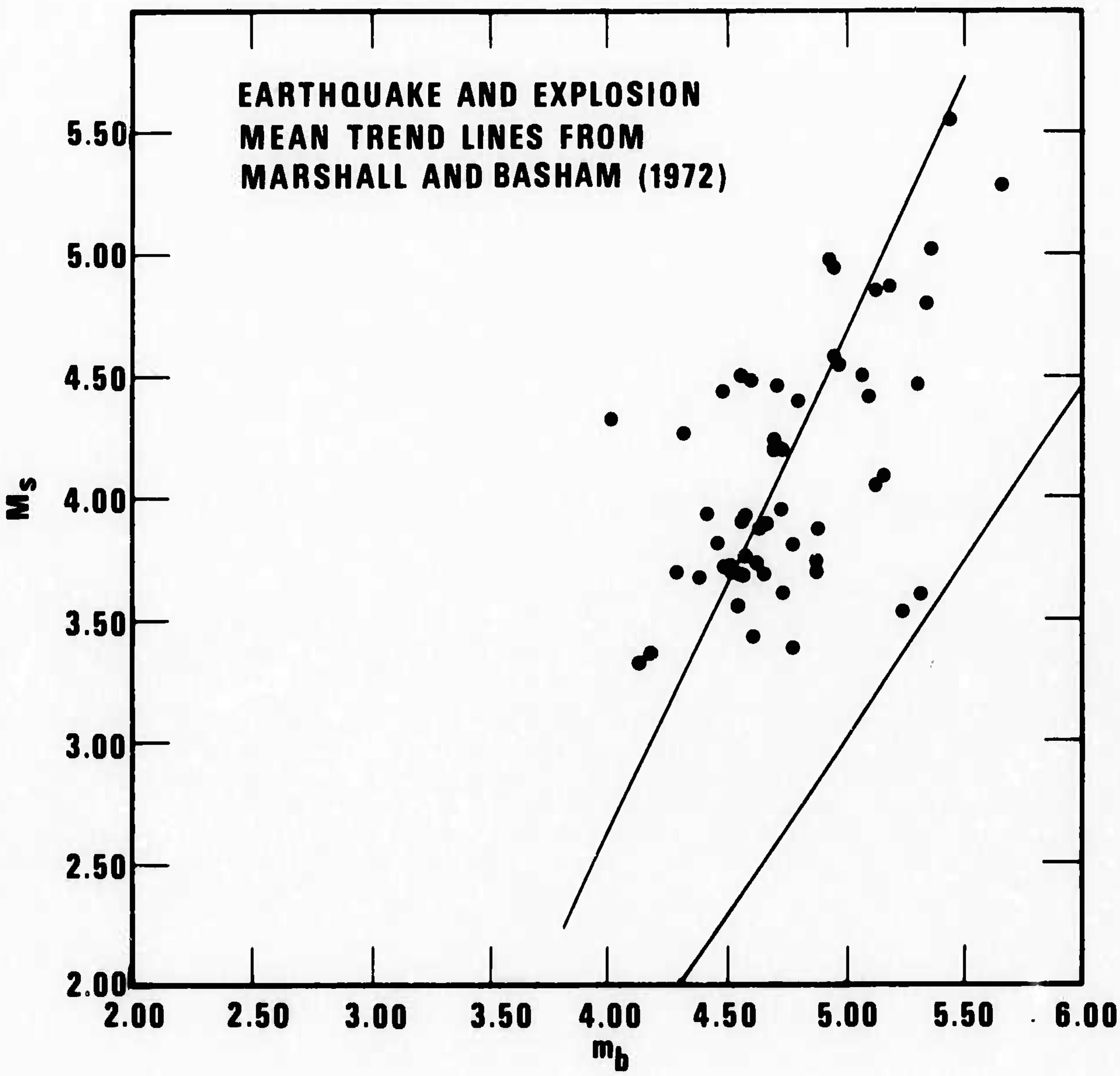


Figure 16. M_s vs m_b values corrected for mean station magnitude differences prior to averaging. Von Seggern's formula was used for M_s.

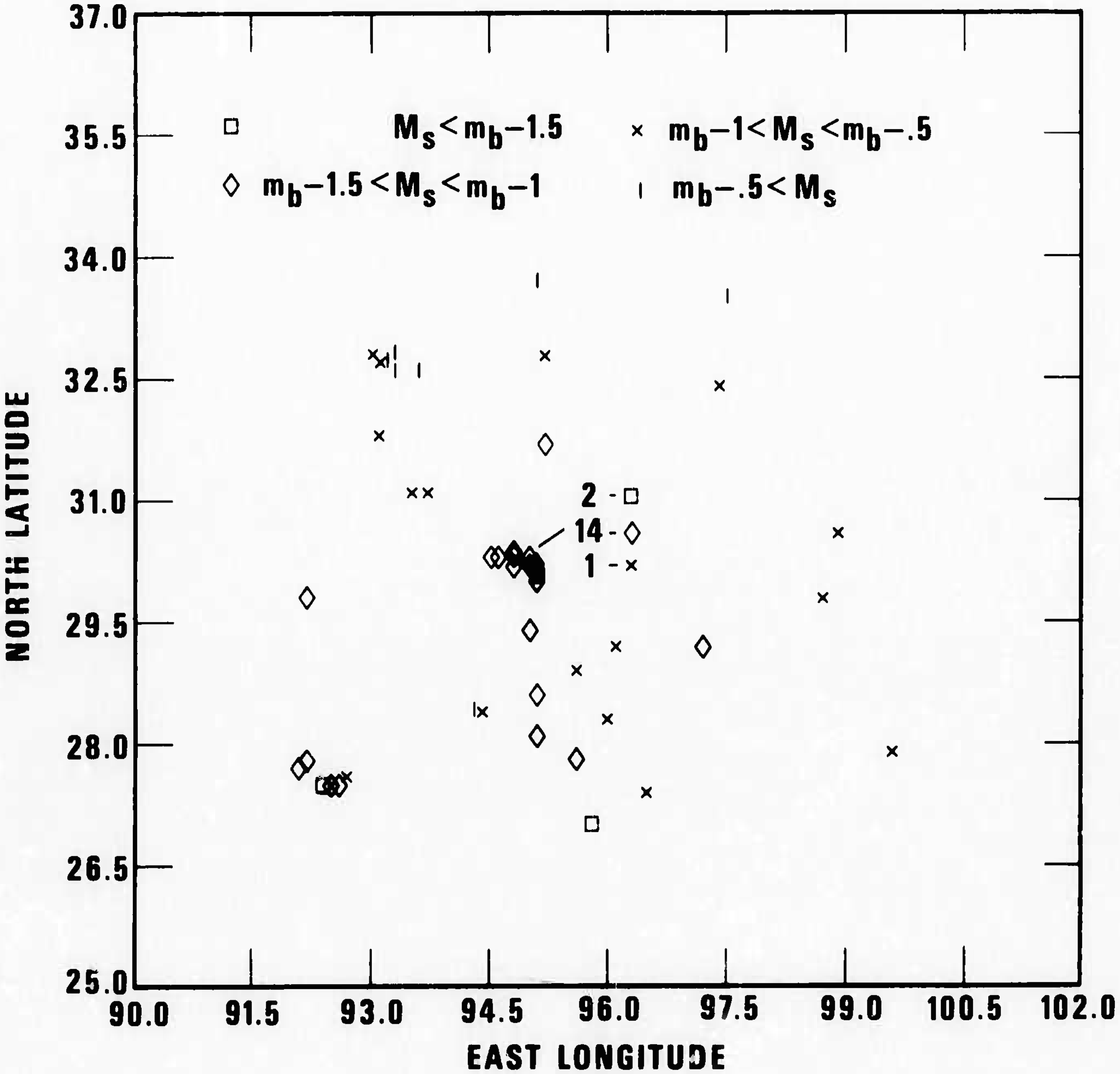


Figure 17. Geographical distribution of various M_s vs m_b types. M_s vs m_b values were corrected for mean station magnitude differences prior to averaging. Prague formula was used for M_s.

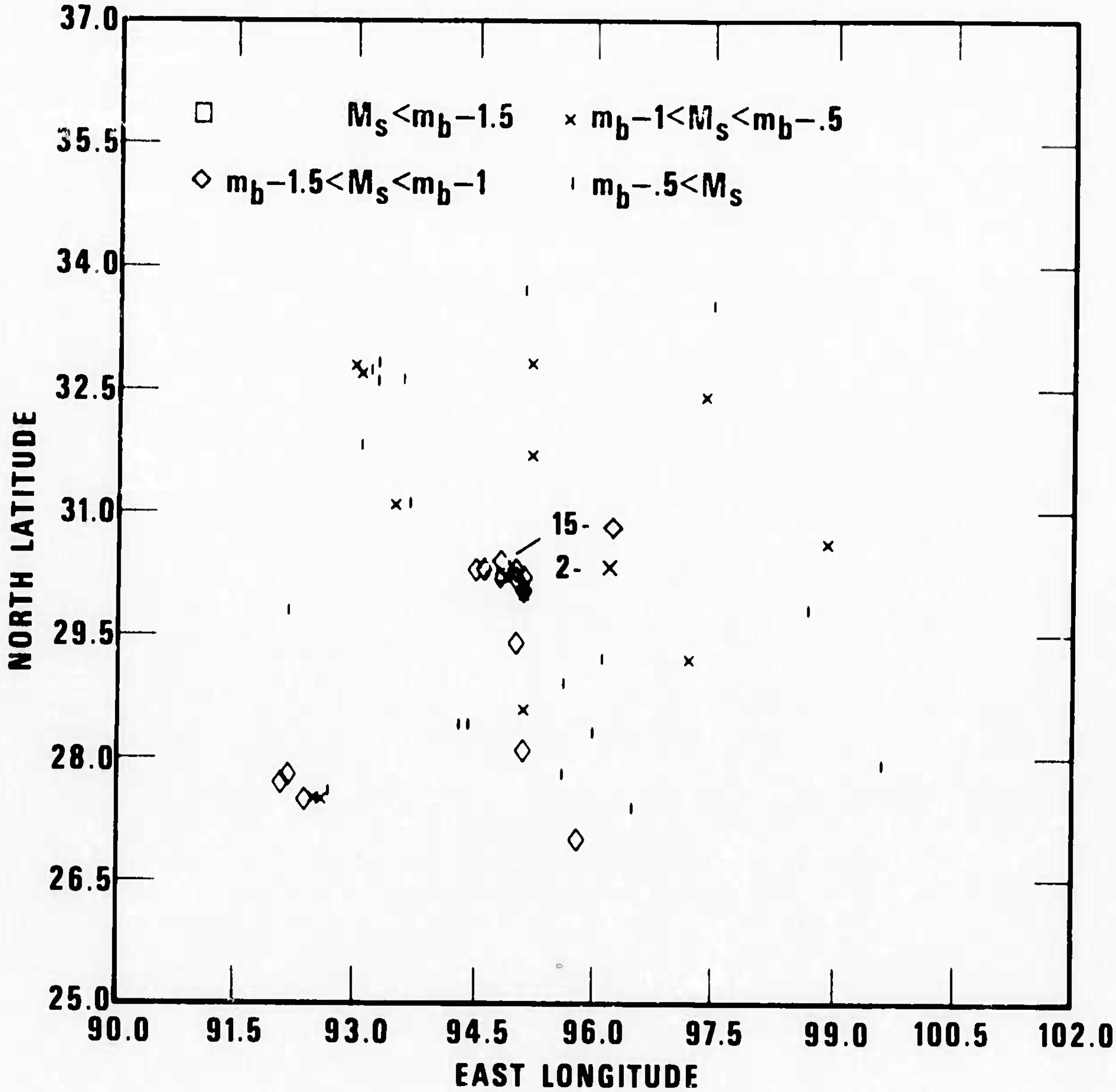


Figure 18. Geographical distribution of various M_s vs m_b types. M_s vs m_b values were corrected for mean station magnitude differences prior to averaging. Marshall and Basham's method was used for M_s, with depth corrections.

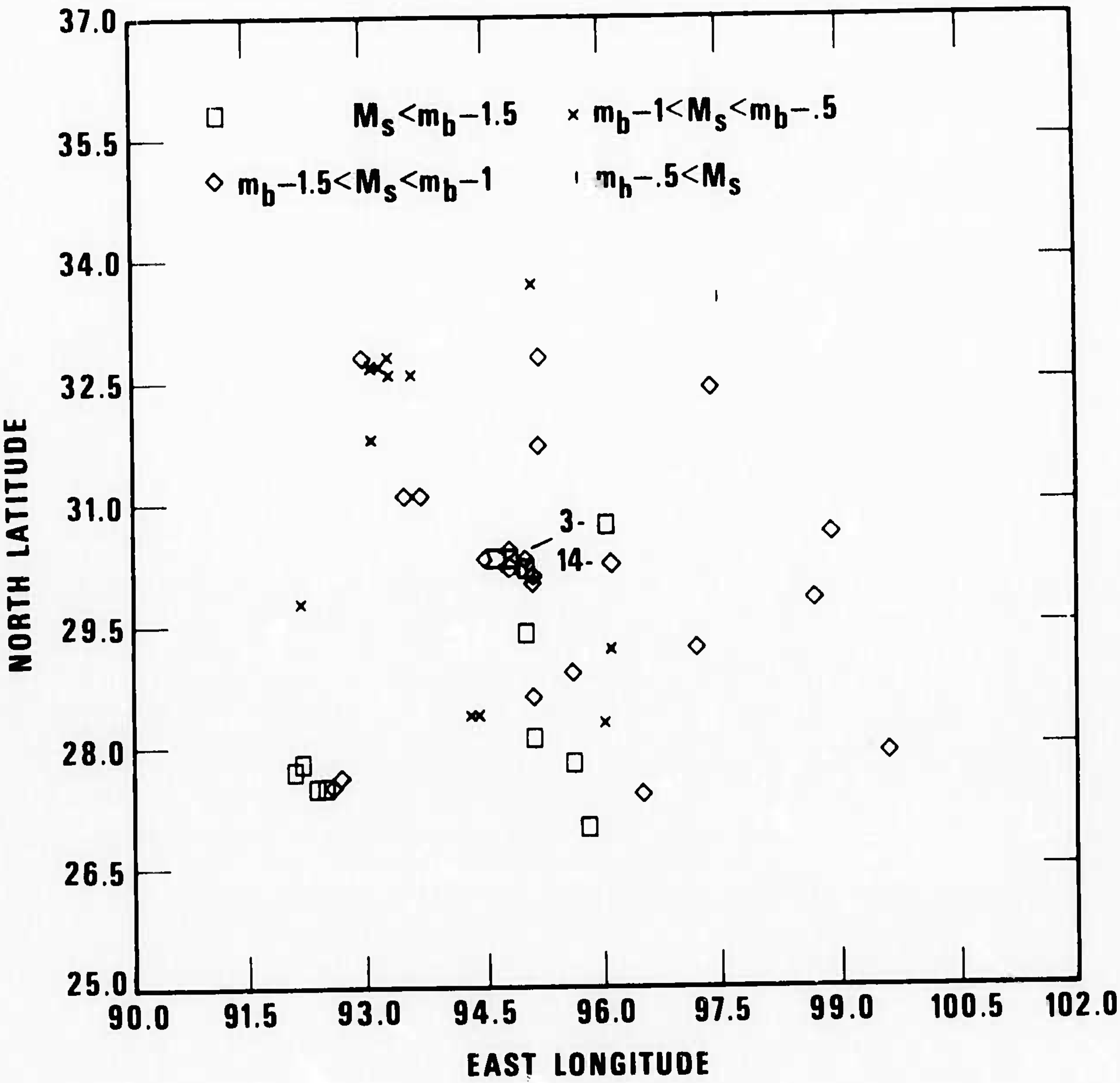


Figure 19. Geographical distribution of various M_s vs m_b types. M_s vs m_b values were corrected for mean station magnitude differences prior to averaging. Marshall and Basham's method was used for M_s, without depth corrections.

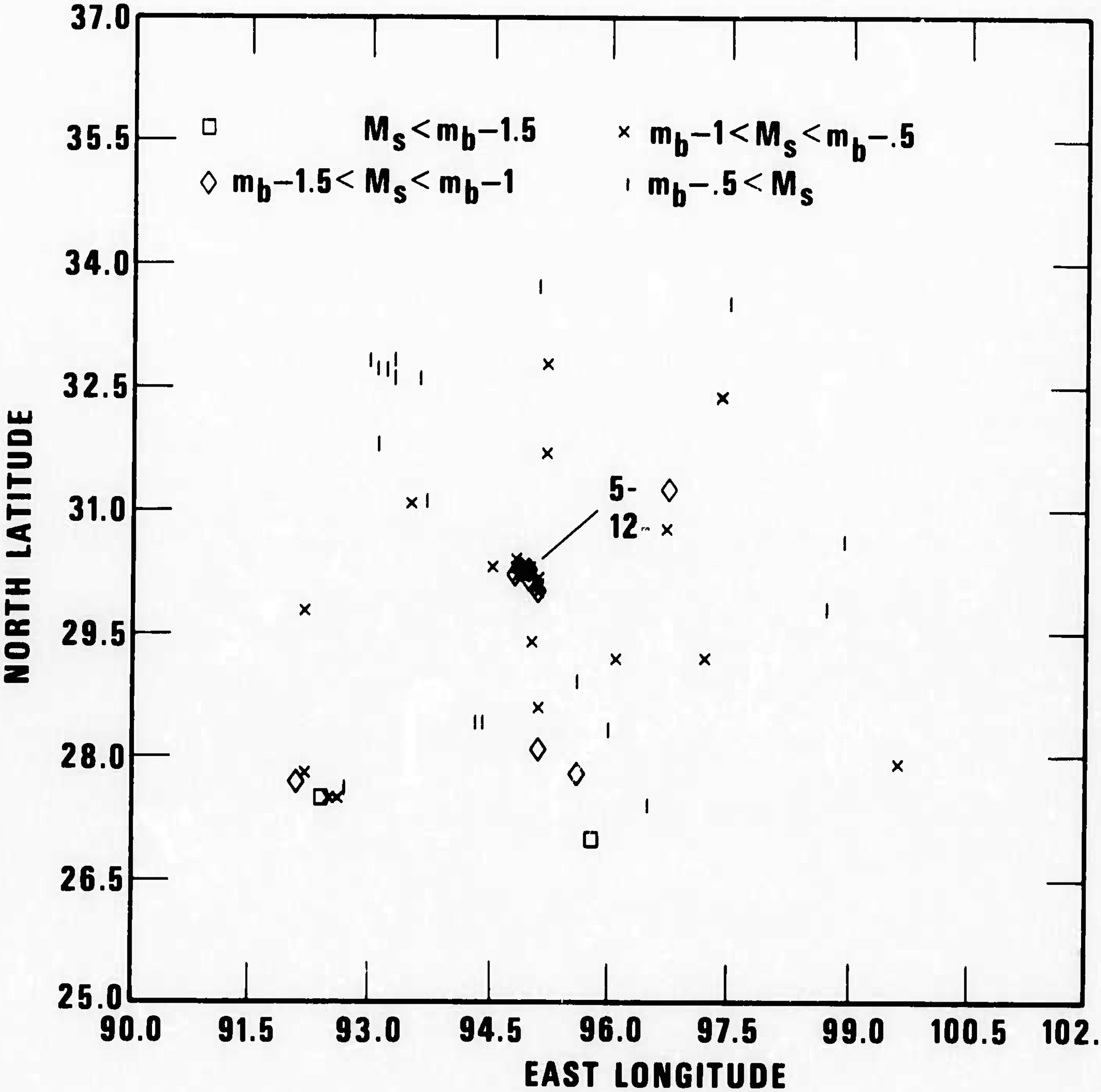


Figure 20. Geographical distribution of various M_s vs m_b types. M_s vs m_b values were corrected for mean station magnitude differences prior to averaging. Von Seggern's formula was used for M_s.

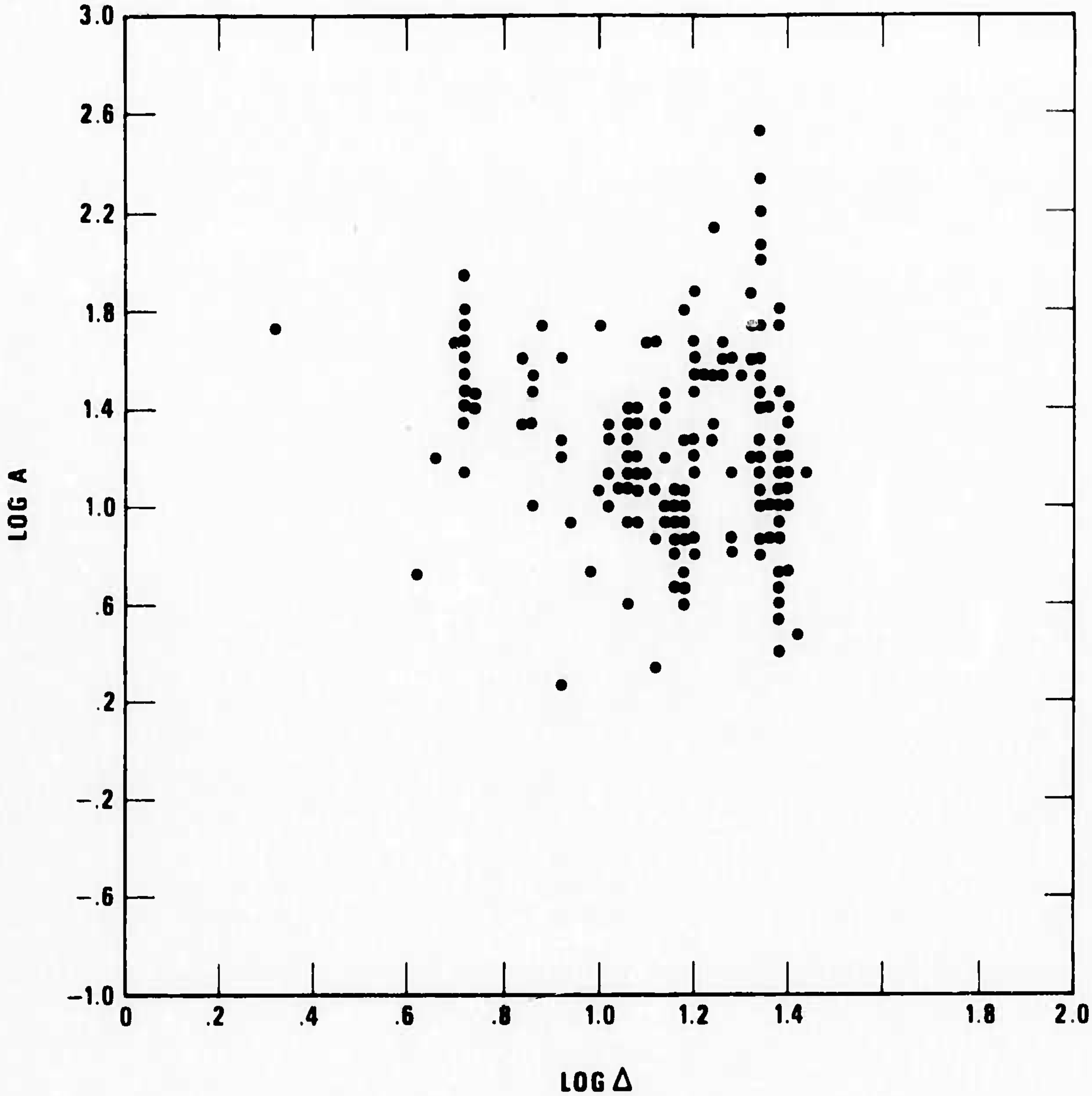


Figure 21a. P wave log A vs log Δ plots before and after the application of station corrections determined by the joint magnitude determination method.

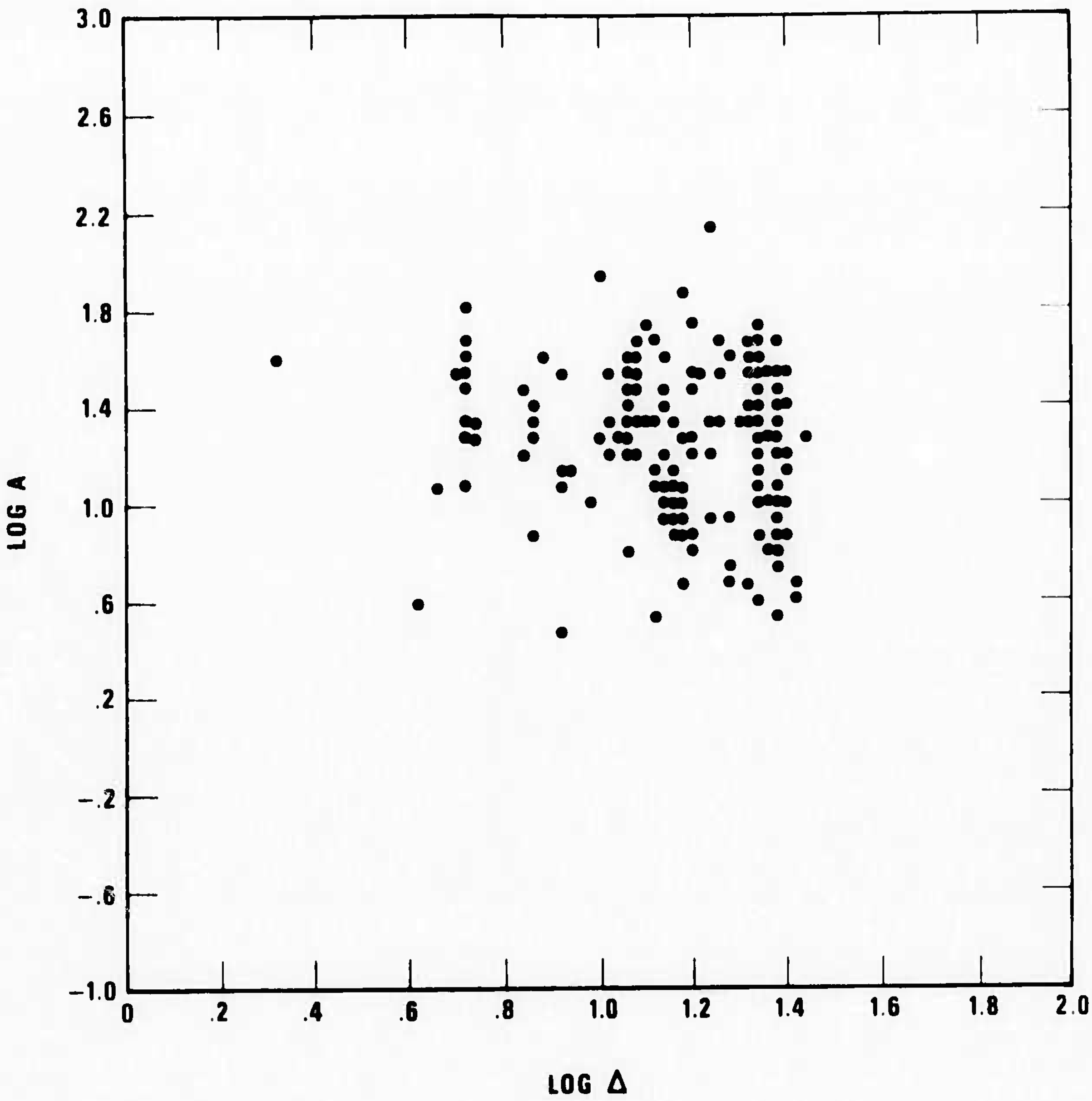


Figure 21b. P wave log A vs log Δ plots before and after the application of station corrections determined by the joint magnitude determination method.

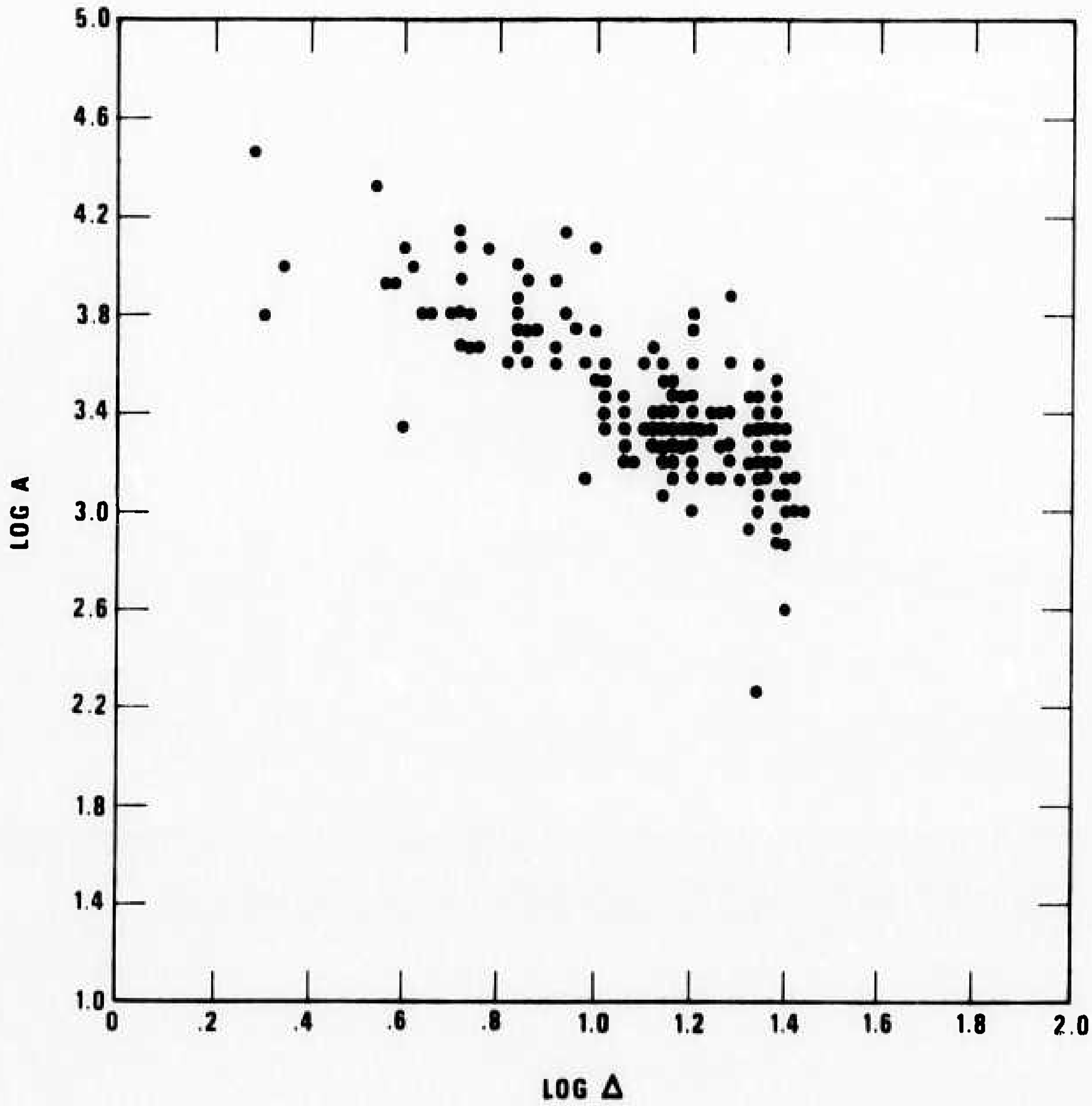


Figure 22a. Rayleigh wave log A vs log Δ plots before and after the application of station corrections determined by the joint magnitude determination method.

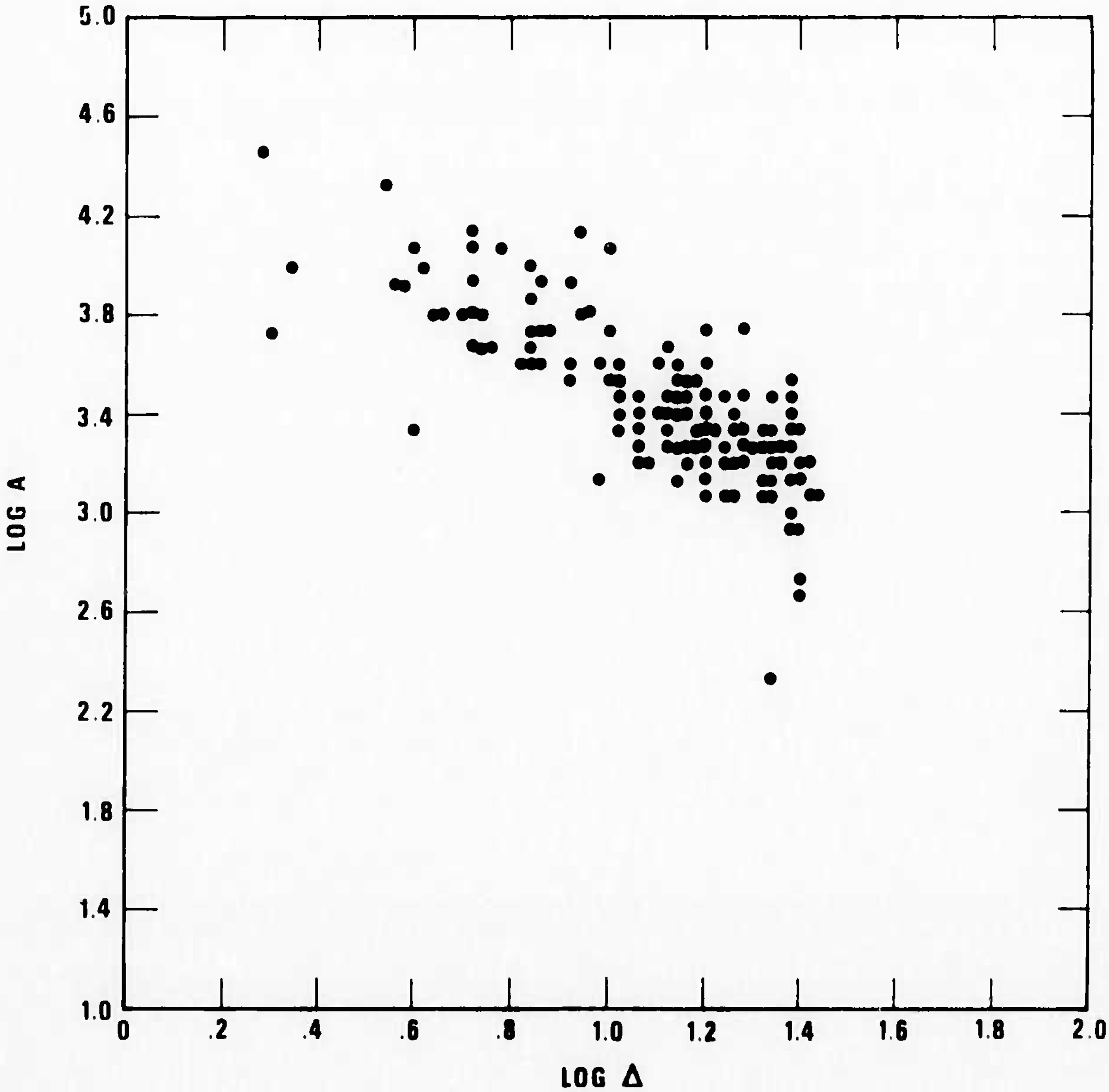


Figure 22b. Rayleigh wave log A vs log Δ plots before and after the application of station corrections determined by the joint magnitude determination method.

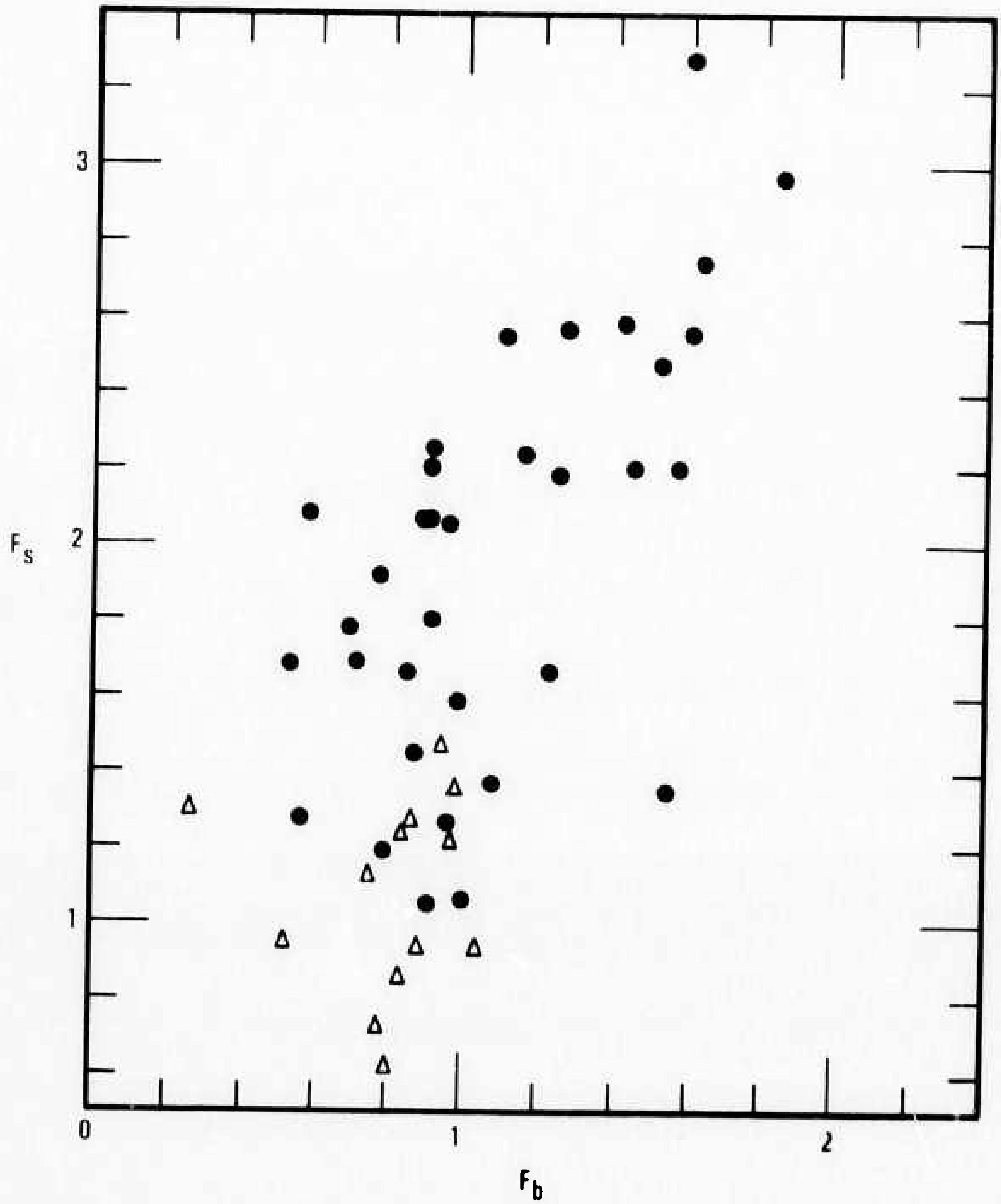
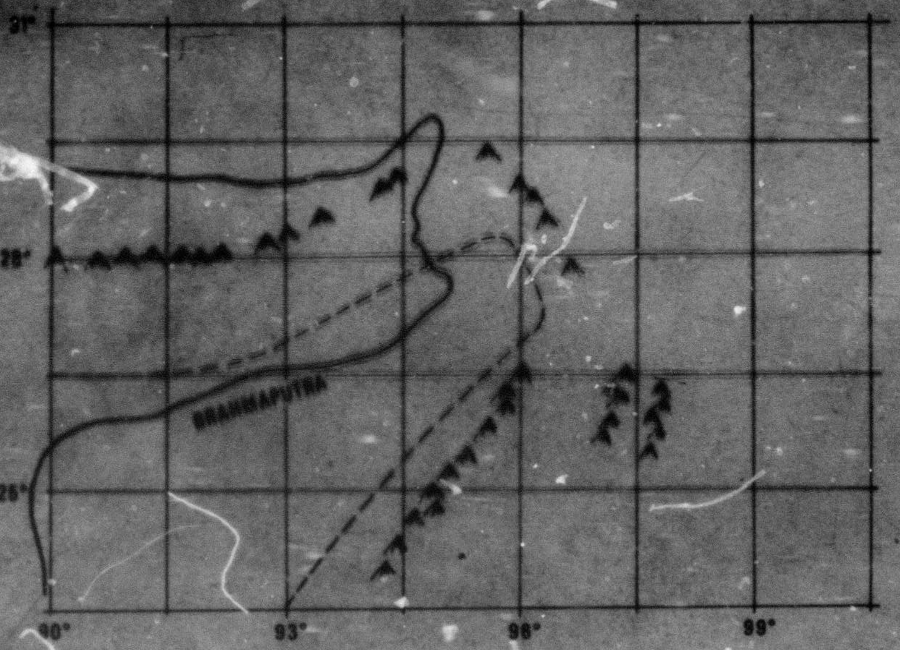
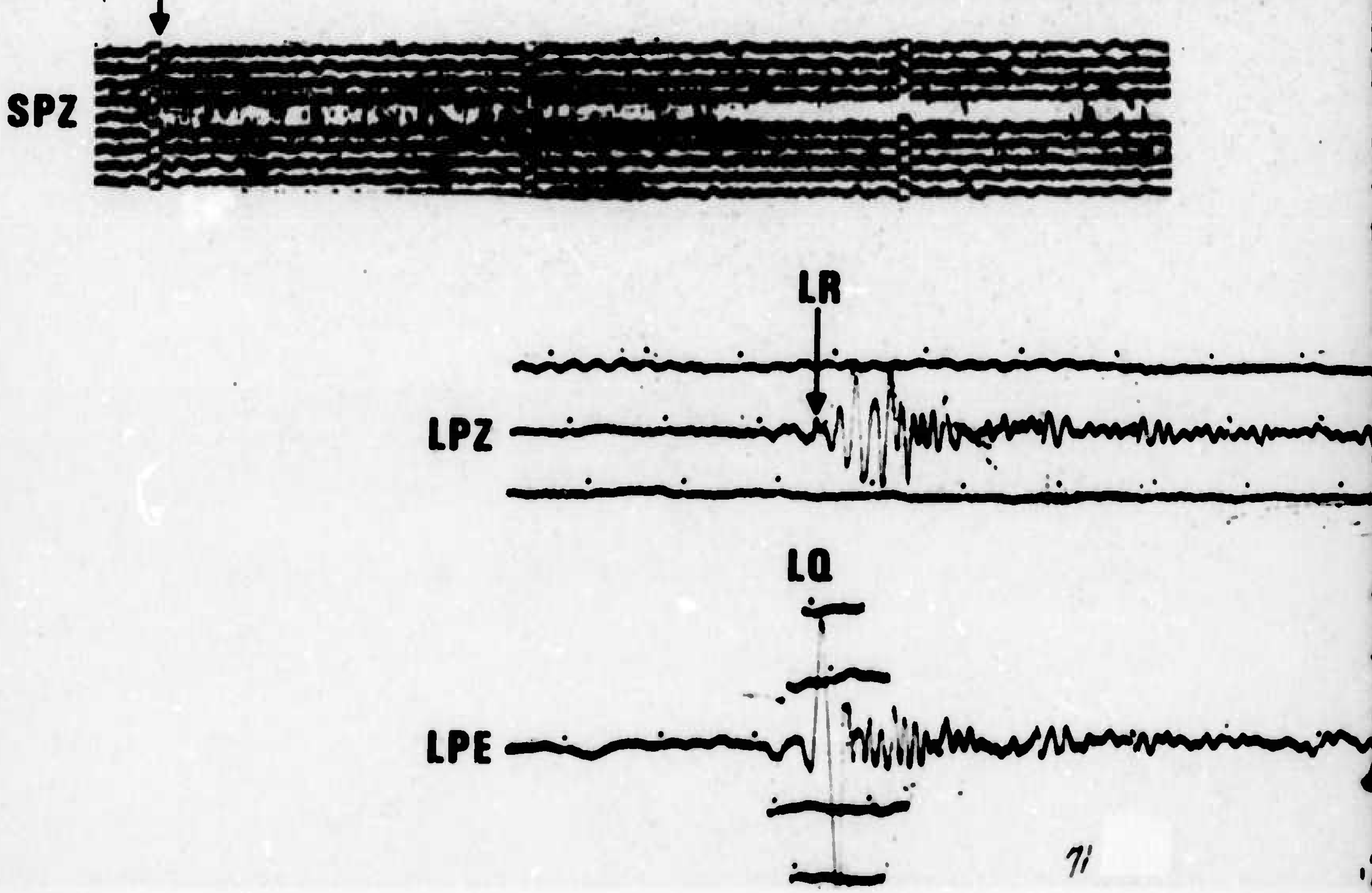


Figure 23. Plot of P wave and Rayleigh wave event factors F_b and F_s determined by the joint magnitude determination method.


31°
28°
25°
90°
93°
96°
99°
BRAHMAPUTRA

EARTHQUAKE 02/16/1968 5:34:54.2
33.7 N 95.1 E
h = 33 km
TSINGHAI PROVINCE CHINA



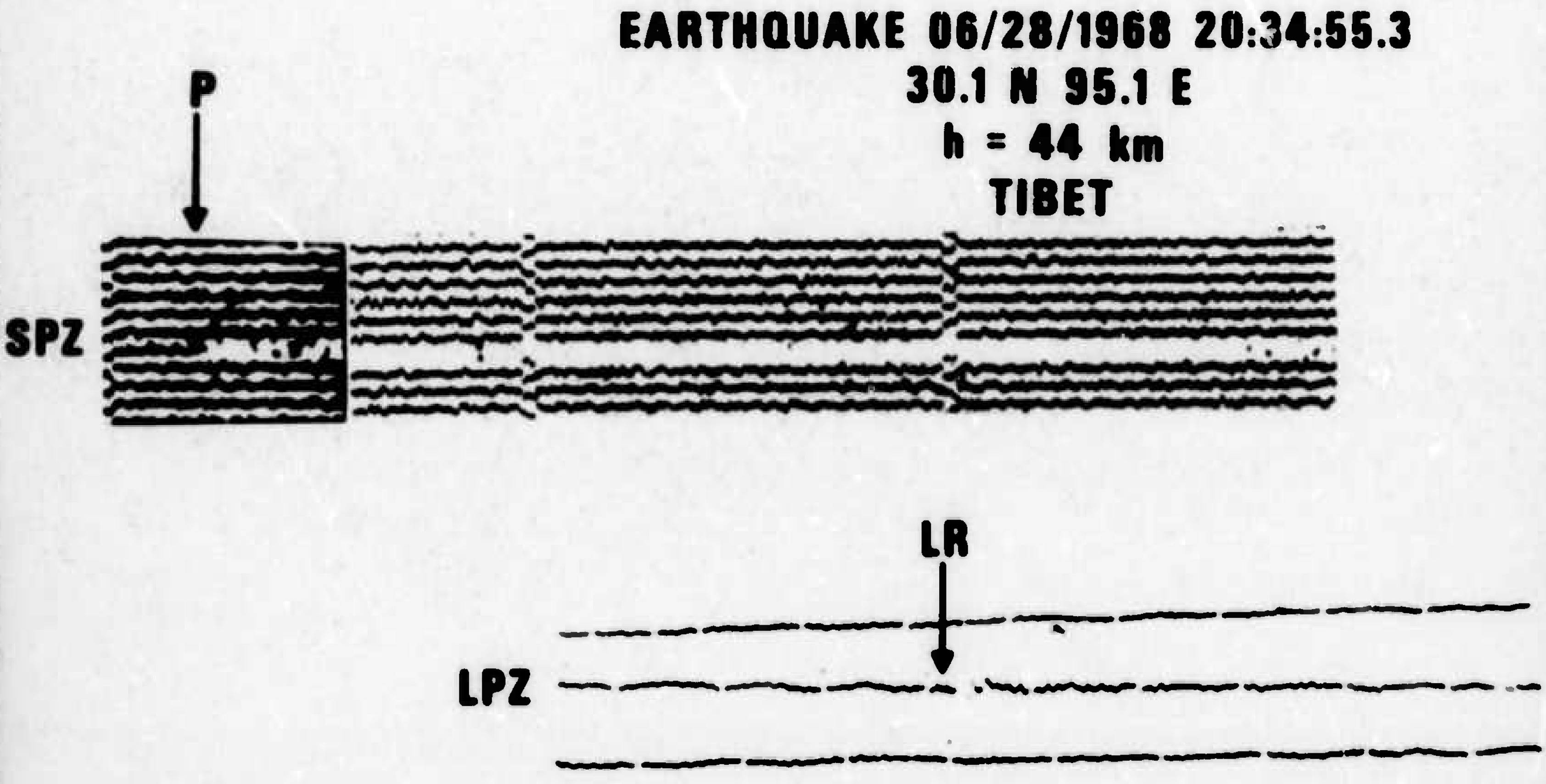
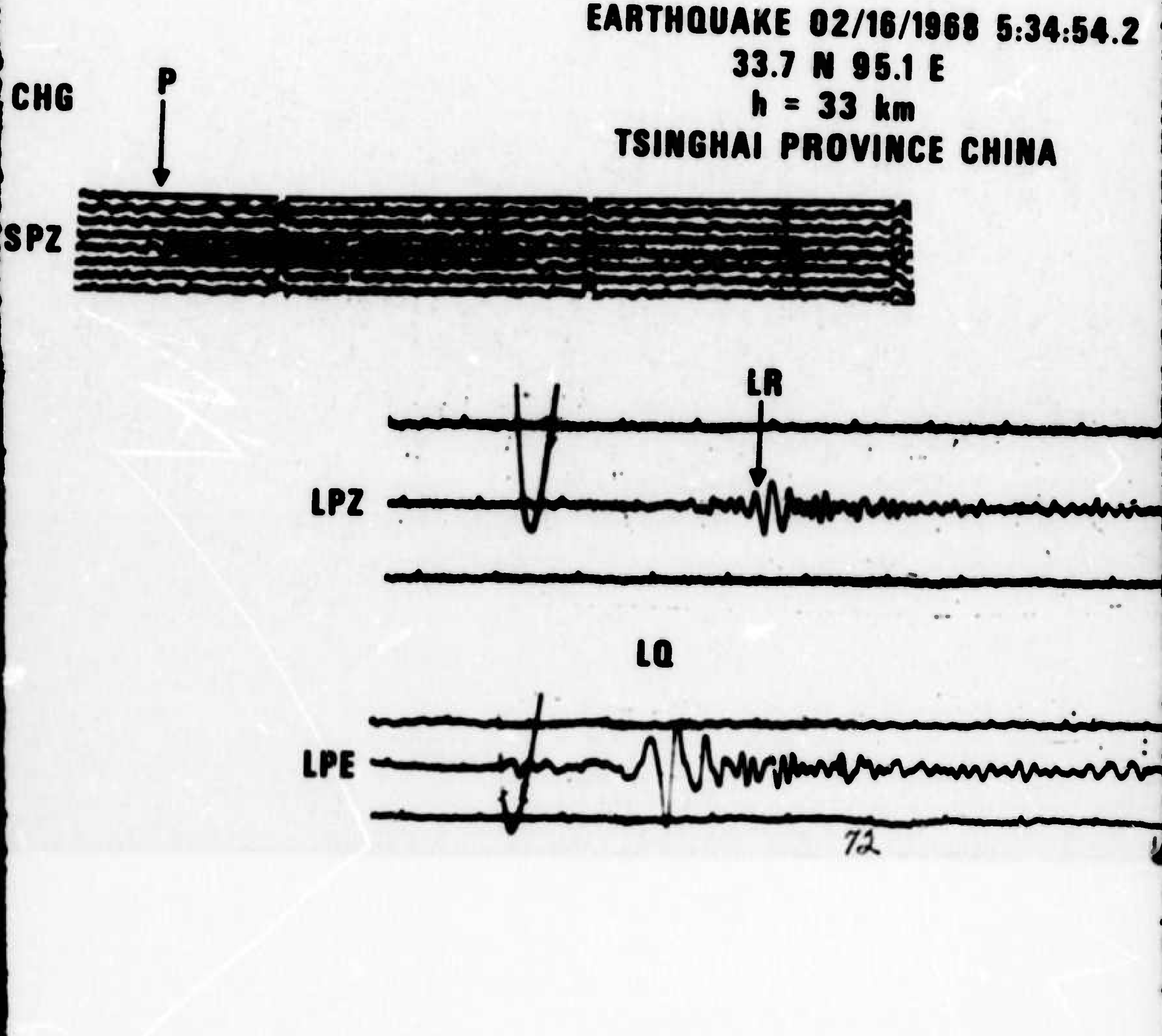


Figure 24a. Comparison of normal (left) and anomalous event seismograms (right)


EARTHQUAKE 02/16/1968 5:34:54.2
33.7 N 95.1 E
h = 33 km
TSINGHAI PROVINCE CHINA
CHG
P
SPZ
LR
LPZ
LQ
LPE

EARTHQUAKE 06/28/1968 20:34:55.3
30.1 N 95.1 E
h = 44 km
TIBET

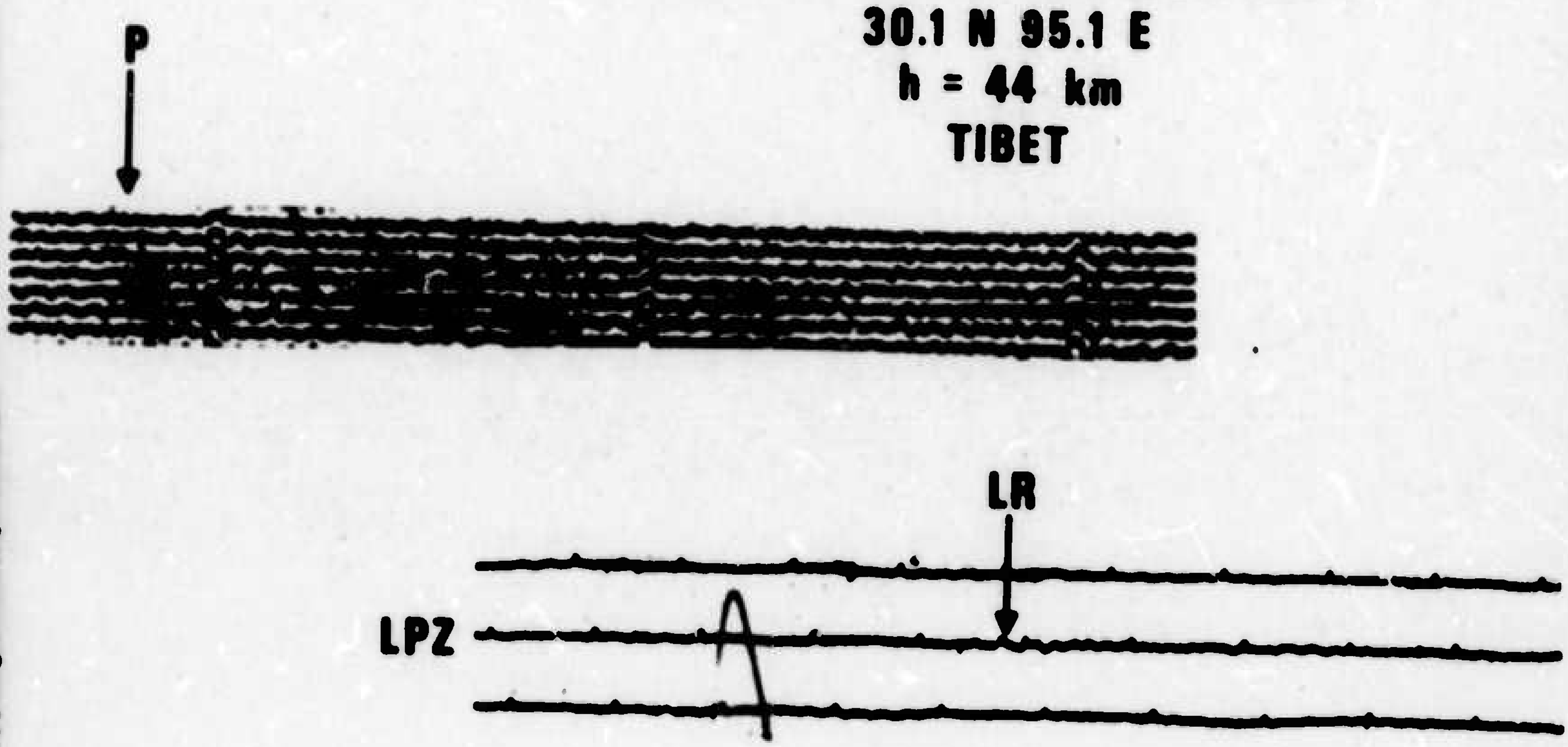
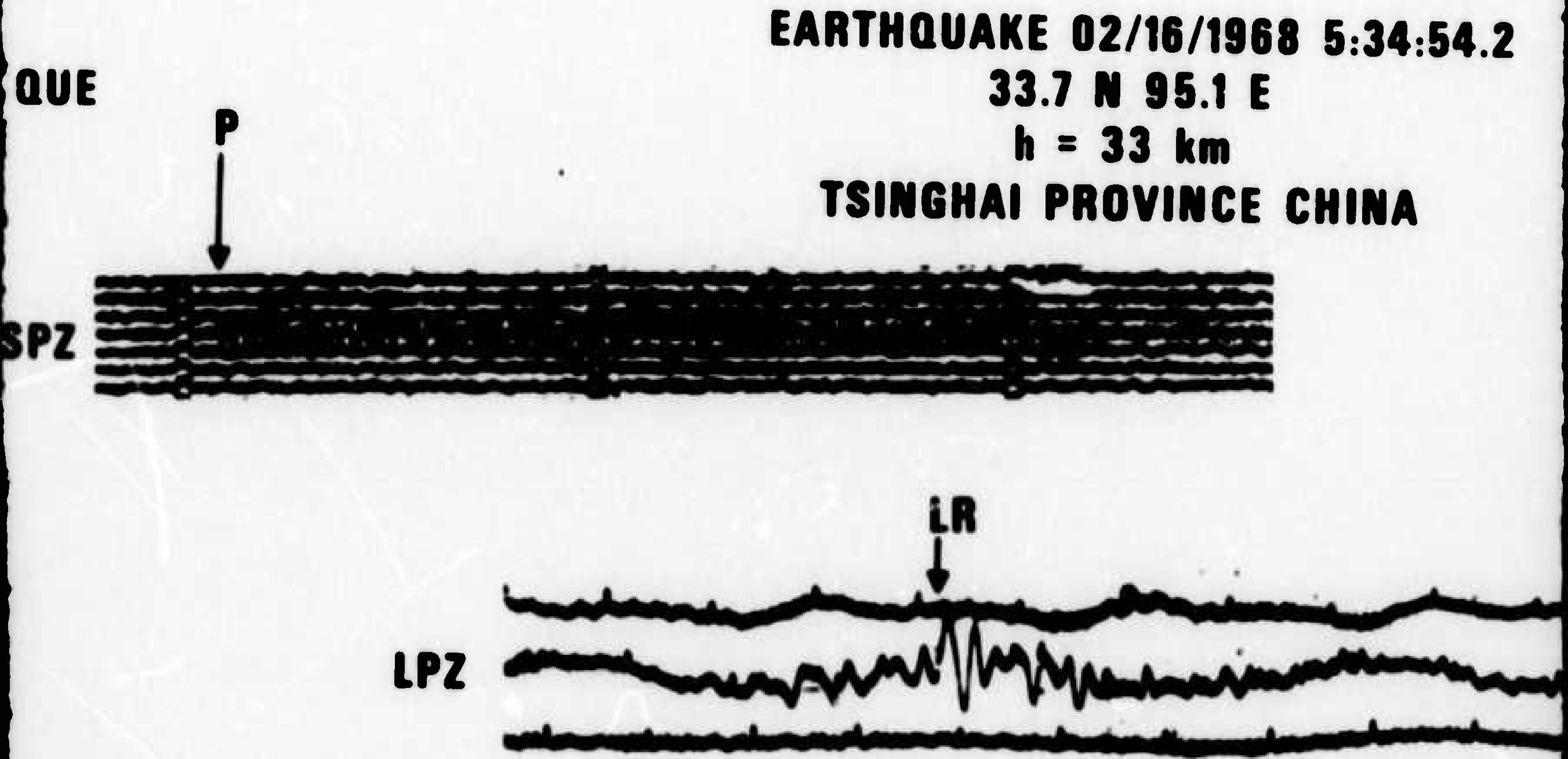


Figure 24b. Comparison of normal (left) and anomalous event seismograms (right).

72a



EARTHQUAKE 02/16/1968 5:34:54.2
33.7 N 95.1 E
h = 33 km
TSINGHAI PROVINCE CHINA
QUE
P
SPZ
LR
LPZ

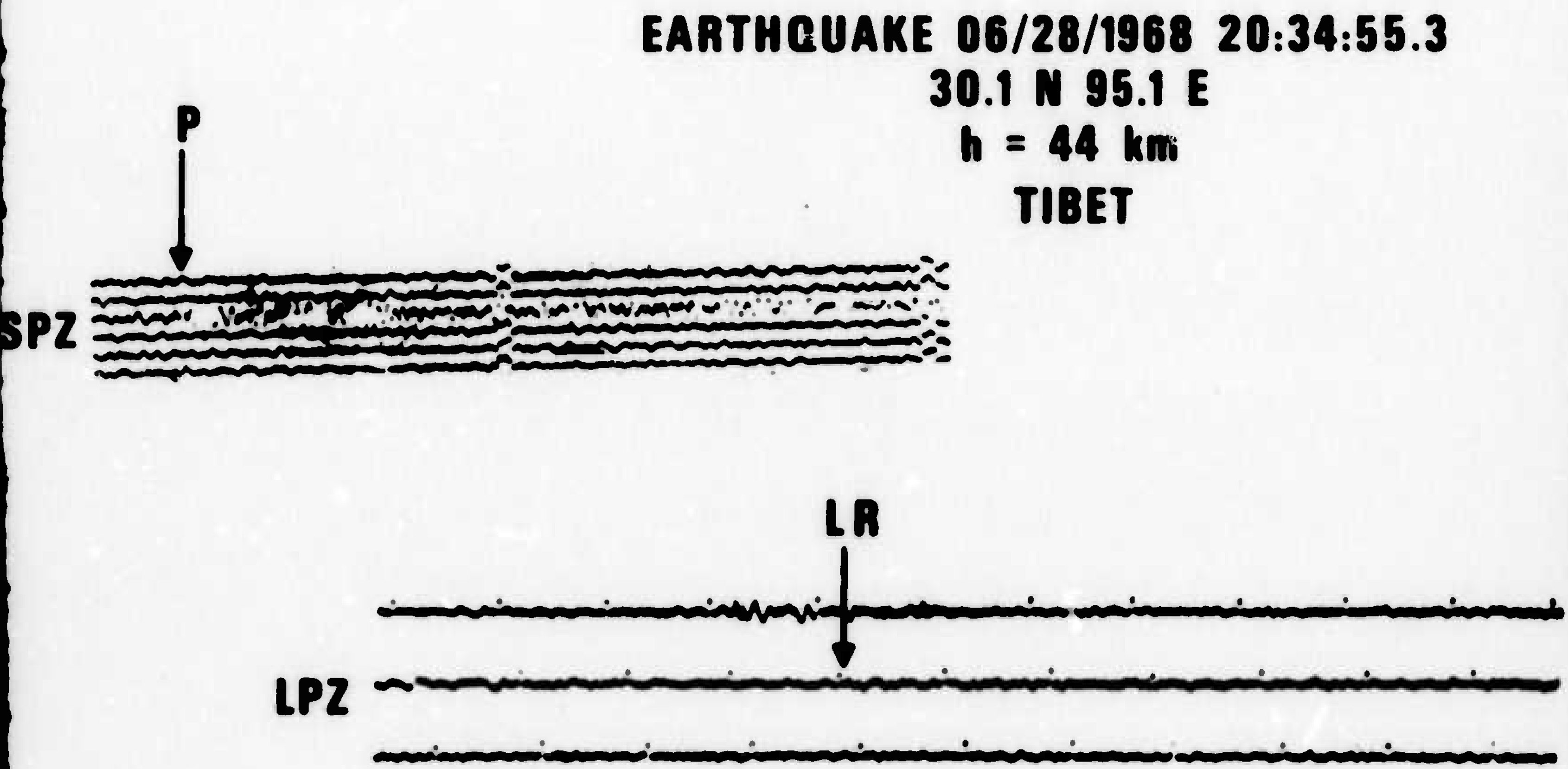


Figure 24c. Comparison of normal (left) and anomalous event seismograms (right).

EARTHQUAKE 02/08/1970 19:07:30.0

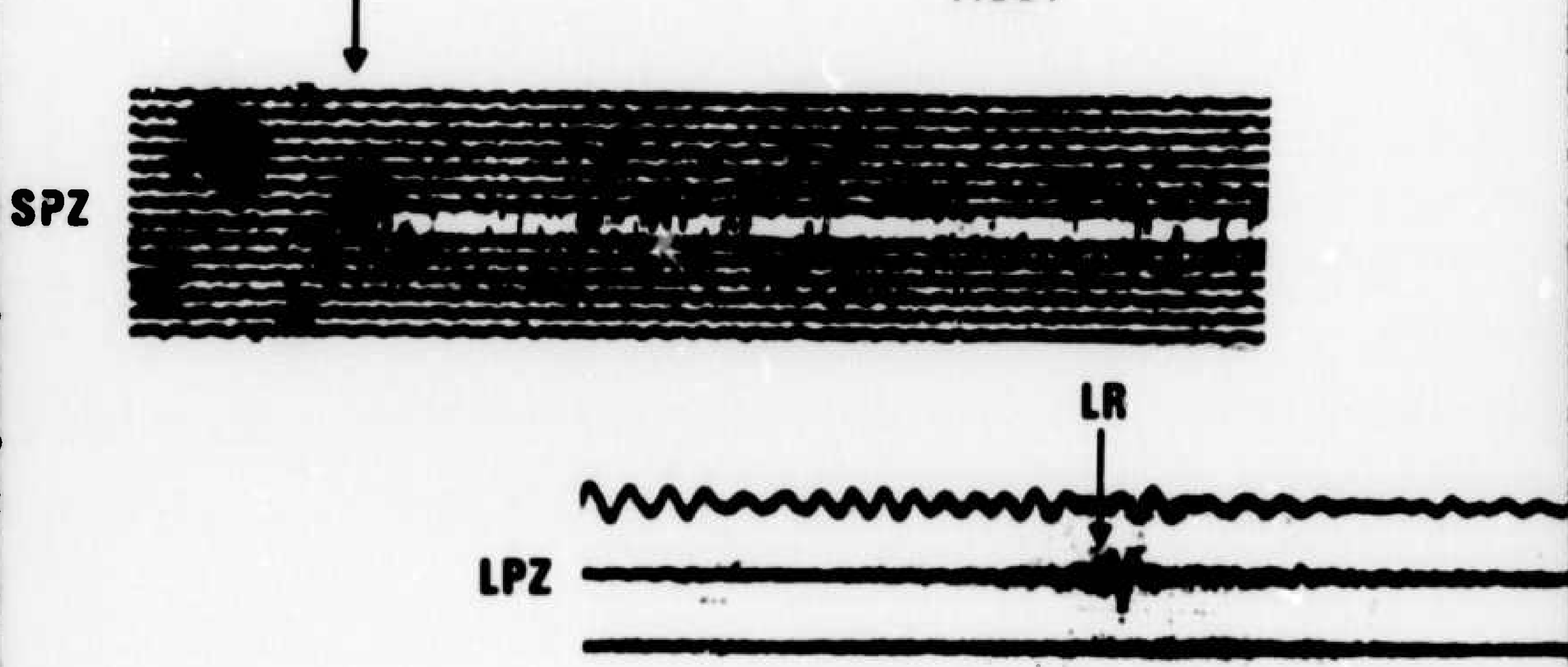
31.1 N 93.5 E

h = 35 km

TIBET

SHL

P



EARTHQUAKE 06/30/1968 5:05:10.0
30.2 N 94.8 E
h = 42 km
TIBET

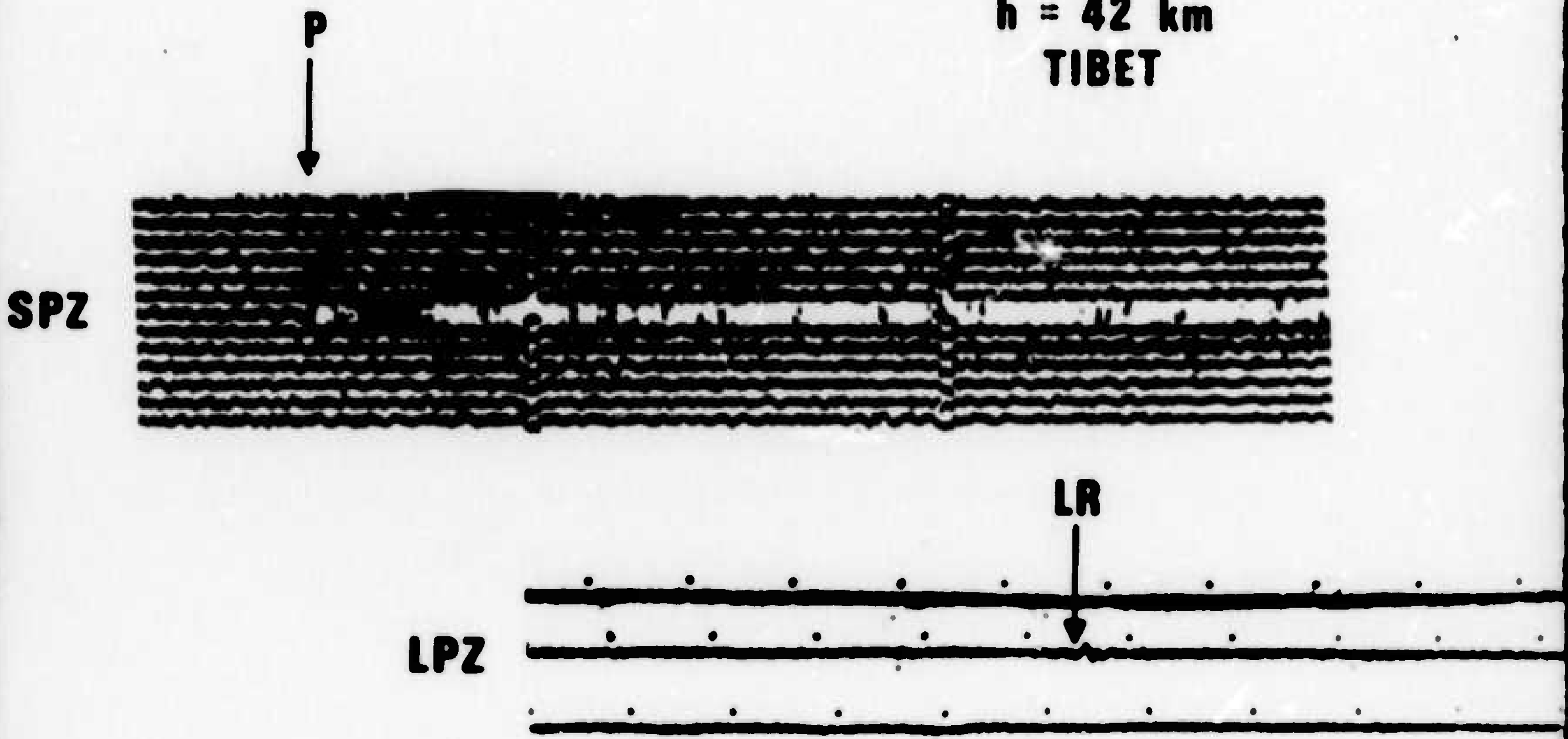
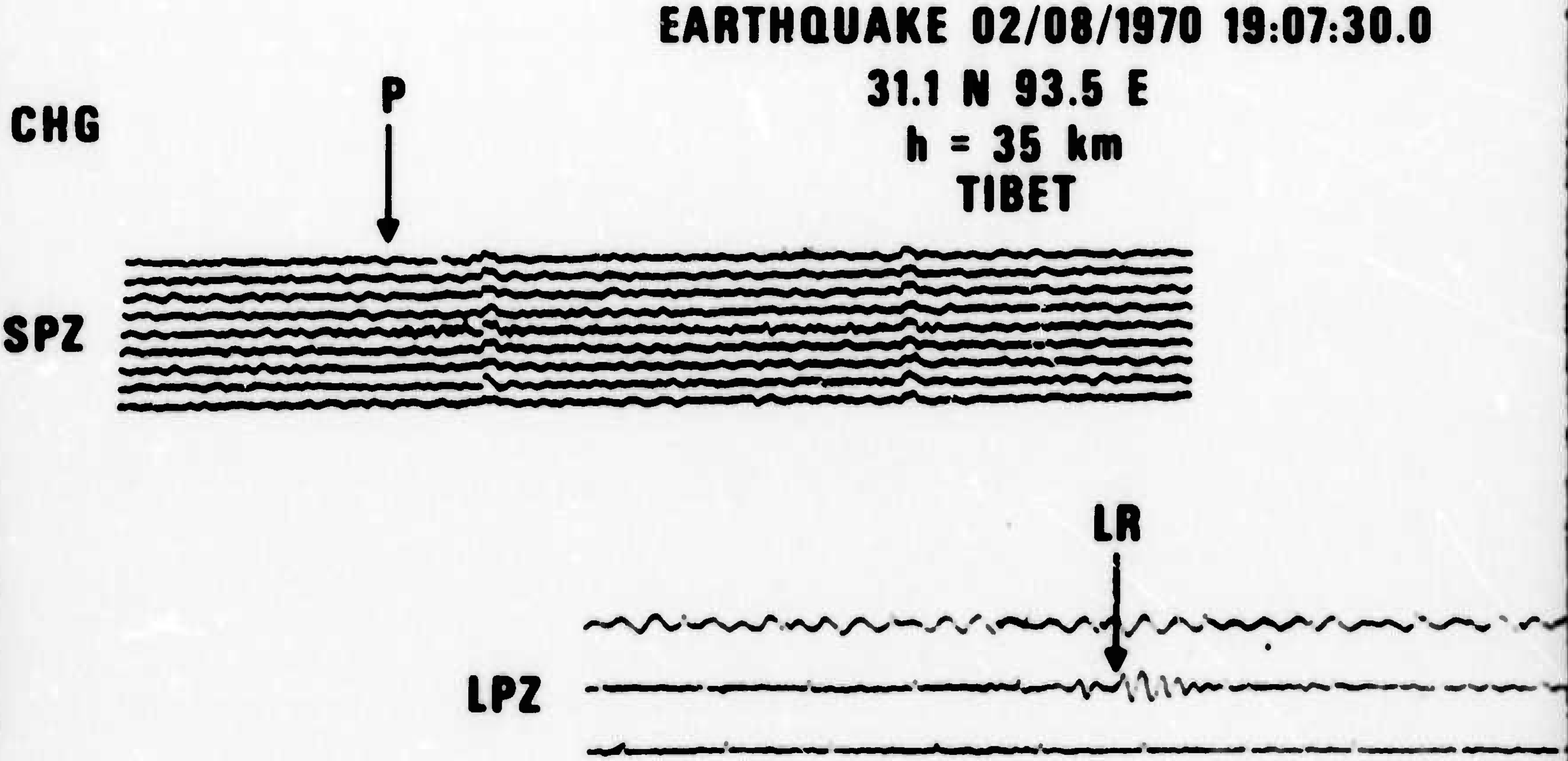


Figure 24d. Comparison of normal (left) and anomalous event seismograms (right).

74a


EARTHQUAKE 02/08/1970 19:07:30.0
31.1 N 93.5 E
h = 35 km
TIBET
CHG
P
SPZ
LR
LPZ

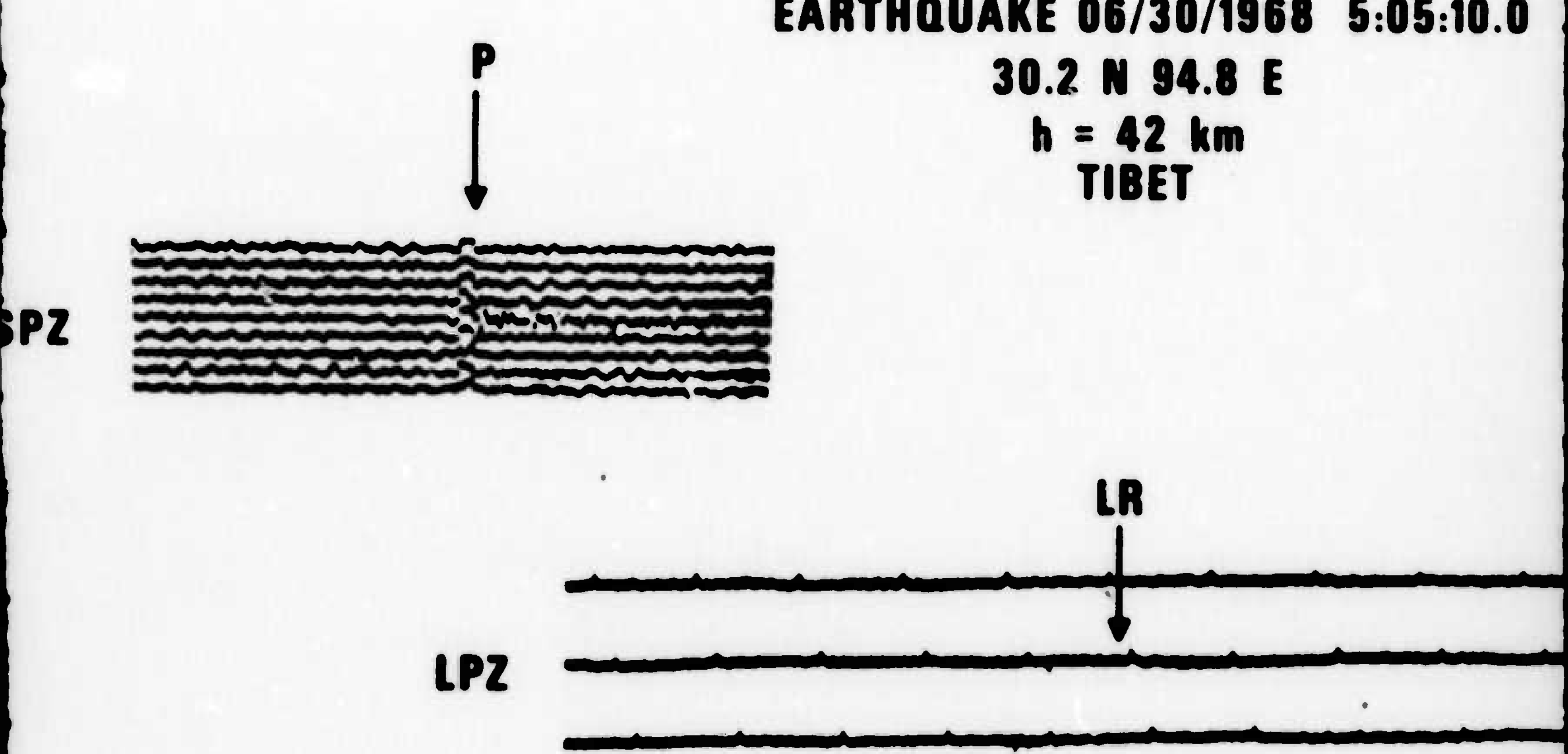


Figure 24c. Comparison of normal (left) and anomalous event seismograms (right).